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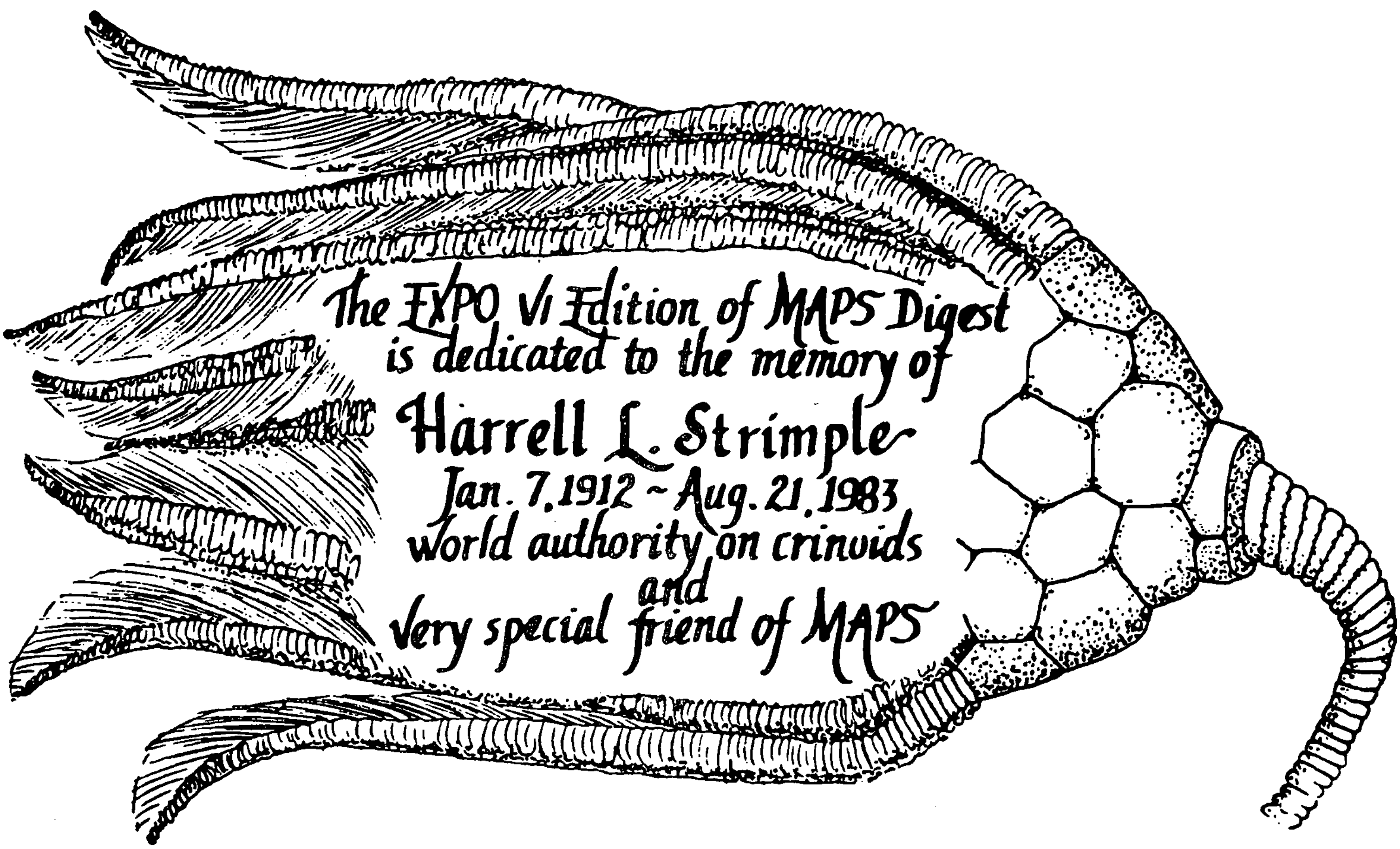

Macrocrinus mundulus
Mississippian
Harrodsburg Limestone
Waveland, Indiana

"A LOVE OF FOSSILS BRINGS US TOGETHER"

IN MEMORIUM--

HARRELL LEROY STRIMPLE

Born:	January, 1912, Yates Center, Kansas
Graduated:	Tulsa Central High School, 1928
Attended:	Tulsa University, 1935 (night School, one semester)
Accountant:	Phillips Petroleum Company, 1933-1959
Consulting Paleontologist:	1959-1962
Curator:	Geological Enterprises, 1960-1961
Research Investigator and Curator:	University of Iowa, 1962 to June, 1980
Tech 4:	U. S. Army Signal Corps, 1942-45
Children:	Son, four grandsons
Married to:	Christina Cleburn Strimple, 1971
Death:	August 21, 1983

Harrell Strimple authored or co-authored 316 publications at least eight of which are considered to be major works. He was a major author of Part T Echinodermata 2 (Crinoidae) of the Treatise on Invertebrate Paleontology.

In an interview by Alberta Cray, Cedar Rapids, Iowa, Mr. Strimple said "Most of my research work has been taxonomic (identification and description of species), phylogenetic (working out natural lineages), morphologic (functional structure) and stratigraphic (dealing with age and position of strata in which material is found). Primarily the research has been limited to echinoderms of the Paleozoic and mainly of crinoids of Carboniferous (Mississippian and Pennsylvanian) age. Geographically the research has spread to far away and unlikely places like a tin mine on Belitung Island, Indonesia, Ellesemere Island in the Arctic, Lake Titcaca in Bolivia. But my personal collecting has been limited to the United States and parts of Europe ranging in North America from the southern Appalachians to the Sacramento Mountains and throughout the Mid-continental region."

"In the course of time I have proposed or co-proposed 4 new subspecies, 537 new species, 1 new subgenus, 105 new genera, 6 new subfamilies, 32 new families, and 17 new superfamilies of echinoderms."

ABOUT HARRELL, from --

Wife Christina, 904 Bowery, Iowa City, Iowa52242--In the beginning, Harrell and I used to tug against each other and then we came to an agreement--I let him have my crinoids, I got all his collecting spots.

Claude Bronaugh, 201 S. Elm, Afton, Oklahoma--My wife and Harrell and his wife were collecting on a marl in Bartlesville, Oklahoma. We had a little dog named Terry. Terry used to pick up slabs and carry them to one or the other of us. On one occasion, Terry carried a slab to Harrell and it had a crinoid on it. The crinoid turned out to be a new genus which Harrell named after the dog. (Mr. Bronough could not remember the spelling so we are unable to include it with this article.)

Arthur L. Bowsher, 2707 Gaye Dr., Roswell, New Mexico--I am a member of MAPS because of Harrell L. Strimple. At the time of his death, Harrell and I were preparing a paper on crinoids. I had not seen Harrell for nearly three decades prior to our meeting in Urbana in 1978 at the IX International Congress of Carboniferous Stratigraphy and Geology. There we agreed to jointly work on a crinoid study that I had underway and Harrell encouraged me to join MAPS because of its excellent work and intense effort on behalf of amateur paleontology. He was a very strong advocate of MAPS. I am glad he recommended membership to me. I enjoy M. A. P. S. Digest even though I am unable to attend meetings of the society.

I met Harrell first in 1939 in Tulsa, Oklahoma. We met and collected crinoids together occasionally. Although we had common interests in crinoids, I was busy at college in Tulsa and Harrell was busy working at Phillips Petroleum Co. in Bartlesville, Oklahoma. We did not meet often. Our interest in crinoids was a common bond. We exchanged separates and corresponded. Our friendship continued as I went on to the University of Kansas, the Smithsonian Institution in Washington, D.C. and then into petroleum exploration that took me to Alaska, Oklahoma, Arabia, California, and finally to New Mexico.

I was acquainted with Harrell L. Strimple and his work in crinoids for nearly five decades. Harrell has made greater contribution to our knowledge of the Crinoidea Inadunata than any other worker during that period. His efforts were a work of love and not because he aspired to greatness. His is a very remarkable bibliography. Harrell is numbered among the great amateurs, although in later years he became a renowned professional paleontologist.

Sometime in the early 1930's Harrell became intensely interested in crinoids that he found in the Plattsburg-Lansing Formation at "The Mound" in Bartlesville, Oklahoma. Shortly afterwards, while on vacation, he visited Dr. Ray Bassler and Dr. Edwin Kirk at the Smithsonian Institution. As a result of discussions with them, Harrell published in 1938, "A Group of Crinoids from the Pennsylvanian of NorthWestern Oklahoma." This first crinoid paper of Harrell's, published privately by him, is characterized by inadequate illustrations and diagnoses. The paper indicates his intense interest in the study of crinoids; he was compulsively drawn to the search and describing crinoids. He continued to publish on his study of crinoids and the quality of his published work steadily improved. His work during the last several decades of his life has been remarkably professional. The improvement of his style is striking after he joined the University of Iowa staff. The intense interest and firm determination to study crinoids led Harrell from amateur to professional status and was responsible for earning him the position on the staff at the University of Iowa.

The story of Harrell's life is an object lesson to members of MAPS. I read in numerous issues, the discussions of amateur vs. professional paleontologist. The field of paleontology, North American paleontology in particular, owes a great debt to the amateur paleontologist.

When our fledgling country was beginning to grow, great effort was expended to inventory and exploit the mineral resources of the territories. Educational institutions were established and the search for knowledge widened rapidly. Emigrants with professional backgrounds, doctors, lawyers and teachers, etc., who fled persecution in Europe found they must in order to survive enter into commerce in the USA. The Cincinnati Academy of Science, the Chicago Academy of Science, and the St. Louis Academy are examples of societies like MAPS that these emigrants developed to satiate their intellectual curiosity in natural science. Paleontology was then in its infancy and was nurtured by these and other societies. The advances in natural sciences, including paleontology, were spurred by the trained naturalists and amateurs who gravitated into these groups. Fossils became important in the search for minerals and fuels because they were an aid in deciphering stratigraphy that often controlled the distribution of minerals and fuels.

Ulirci, Bassler, Foerste and Schuchert first began collecting fossils as children in Cincinnati under the shadow of the Cincinnati Academy of Science. None had formal education in biology or paleontology. Schuchert became a world renowned professor of paleontology and geology at Yale University. Ulrich and Foerste were world renowned for their study of early Paleozoic fossils. Bassler was the world's outstanding authority on Bryozoans and Ostracodes. He became Curator of Paleontology and Geology at the Smithsonian Institution. Thomas Jefferson, although a lettered scholar, was an amateur vertebrate paleontologist and had fossil bones in one room of the White House. Wachsmuth, who bequeathed the Wachsmuth crinoid collection to the University of Iowa, was a physician from Germany who owned and operated a hardware store in Burlington, Iowa. Frank Springer, long time partner with Wachsmuth, was initially an amateur crinoid enthusiast but went on to become one of the world's primary authorities in crinoids. Our history is rich in the work of these and other amateur paleontologists.

I submit then, that as a person perseveres in the objectives of MAPS, he might well progress from beginning amateur to professional. Is it then necessary or advisable to dwell on the classification? Should "The Profession's Corner" not be called "The Research Corner" (Ed. Comment, I love it! It's done!) or "The World of Fossils" or some other title. The title "The Professional's Corner" seems to me to create an undesirable schism in MAPS. We are all students of natural history, some beginners, and others are more advanced.

Let us be aware of the example of Harrell L. Strimple's life. Through intense interest and self-education he moved from amateur to professional paleontologist. But he remained an amateur at heart also. He gave unstintingly of his time and knowledge to others; especially young people so that they might grow in knowledge and enjoyment thereof. The "Book of Gold" is inscribed with his many good deeds to his fellow man. The knowledge of crinoids is greatly advanced because of his work. I am glad I knew and worked with Harrell L. Strimple. We shall miss him.

Al Hartman, Box 96, 301 Hartman St., Waterloo, Illinois--There's a lot of joy in talking fossils and "fossil fanciers."

There was an interesting out cropping of Upper Chester Series "Renault Formation", about 4 miles east of Waterloo, on Walter's Creek. The north side of the road bank was especially prolific with pentremites, archimedes and crinoids. The limestone strata lay in horizontal joints, and Harrell had devised a scheme to swing out some of these joints on hinges as it were, to expose the extremely fossiliferous shaley layers between the joints. He must have had quite a display at the time--of rocks seemingly springing from the road bank--and had discovered an interesting "swarm" of micro-crinoid crowns, when Clem Felker, a 6'2" 250# very German bricklaying contractor who owned property at nearby Dove Lake descended upon poor Harrell with storm flags flying. Clem ranted and raved that was his property Harrell was destroying (actually it was a county road bank), and warned him off at once. Of course, Harrell left at once and went back to Iowa, but was back the next week to tell me about it. I knew Clem well--he and his three huge sons built our house in 1960. Harrell and I went back to the spot collected the crinoids, tucked the limestone joints back in the bank neatly for Clem to see and never had any more trouble from Mr. Felker who was as Teutonic as Harrell is not.

Harrell used to have an old blue or green jalopy that rode awful low in back. Maybe the springs were weak, or maybe there were a lot of specimens in the back seat and trunk. Harrell believed in collecting in volume and getting it back to the lab before freeing the specimens from the matrix. Our children were small, still downstairs with us, and Harrell stayed in our upstairs room. My wife enjoyed him as a guest and made big breakfasts for him. On days off from my oil company job I showed him new sites.

One such was the Paint Creek Formation (now called "Beech-creek" limestone) near Vogels School in St. Clair Co. where the old Belleville Bridge crossed the Prairie du Long Creek there was a great greenish gray shale bank loaded with fossils of the upper Chester Series, and then just up stream--a great red shale bank likewise loaded. It was not a new fossil bed. John James Audubon visited it in 1812. It was made into a "platform of death" back 300 million years ago when the Earth between Dupo and Waterloo achieved a great hump or fold (Dupo Waterloo Anticline) and the area was much fractured and faulted. But this day Harrell and I stayed in the wooded areas above the creek and its steep shale banks. We followed the little ditches & gullies washed through the woods and found several dozen slabs--some quite large with complete crinoid crowns arrayed on them. Our car was some what far behind (it was my car, since I refused to go in the dirt road in Harrell's old jalopy) and we worked and struggled to lug the slabs to our transportation. I can vouch that Harrell really sweats for his profession.

On another occasion I took Harrell down to Ames, Illinois, to the county line between Monroe and Randolph County at the head waters of Paint Creek. Stuart Weller, state geologist and his survey party came through here in 1910, as his son J. Marvin Weller later told me. (J. Marvin was then (1910) a 10 year old). There were several type localities on this farm "Yankee form chert", "Paint Creek", etc.

Extensive hiking is necessary but Harrell was up to it. The great red clay banks at the Paint Creek formation were a source of paint for the early settlers' barns--thus the name. Again the green shale was profuse with pentremites, brachiopods and archimedes etc., but Harrell wriggled through some barb wire fences into some narrow rock strewn draws and gullies coming down from the uplands, and we were soon handling slabs with complete crinoid crowns. Later, on his own, he found many spots along the Ames road that yielded crinoid crowns.

Seems like every time Harrell had some new papers printed he sent me a copy or copies. Originally I had an accumulation of Oklahoma Geology notes. A great deal of the fossil material was written by Harrell Strimple who collected there. There are also papers, yellow and brittle with age by Strimple (why! he must have been barely out of his teens in the 30's). I acquired an Index Fossils of North America in the mid 40's with Strimple listed as an authority. Many of his papers are from foreign countries and describe species from all around the world and the South Pole.

When he rode with me in the car he was writing, writing, writing all in his scientific, ready to print manner.

The Geology of Glassgow book was a gift from Harrell. He must have treasurered it but gave it to me. Scotland was where a lot of geology as a science originated. (I don't have a photo of Harrell--he wasn't much for pictures. My sketch is awful, but that's the way I remember him).

Doug DeRosear, Box 125, Donnellson, Iowa--Usually when I went to see Harrell and Christina, I would take along a few of the latest crinoids I had found, either to show what I had unearthed or perhaps to gain a little more understanding of what I had found. Harrell once told me that he hated collectors handing him a crinoid and expecting a snap identification. Harrell would usually not give me an exact identification but would tell me where to look in order to get that ifentification which meant that it was a good learning experience for me.

I always felt a little guilty when I went to see Harrell and Christina. I guess I always thought Harrell had more important things to do with his time. However, when I did go see them, he would always put away what he was working and seemed most happy to see me. He was always very generous with his time and knowledge. We would usually go out to eat somewhere and I think I was allowed to pick up the tab only once, so he was generous in that way also. He was very generous to me with his collecting sites, as he knew if I found anything unusual or undescribed, I would give it to him. He had so much to offer. Sometimes we would talk about fossils and sometimes we would talk about other things that friends usually talk about.

One time I took a small flexible crinoid from the Burlington to show Harrell. I did not know what it was other than a flexible crinoid, but I was pretty proud of it as it was complete and in very good condition and complete flexibles are quite rare from the Burlington Fm. Harrell glanced at it rather briefly and then after a few minutes, picked it up and started looking at it intently. He walked into the other room and began grabbing books off the shelves. He began to get a gleam in his eye as he told me that it was undoubtedly a new species and perhaps represented a new genus as well. The rest of the afternoon was spent studying the crinoid and the paleontological literature as Christina kept telling him to put the crinoid down and get back to visiting. Christina's advice seemed to fall on deaf ears. Harrell was INTENSELY studying the crinoid.

As I drove home that evening, I was very pleased that I had finally contributed something to Harrell. A few days later, I got a call from Harrell stating that he had stayed up quite late the night I had been there. He had studied the crinoid and had even drawn a picture of the specimen. While he was finishing up his drawing, he noticed that the crinoid had only four rays developed, something we had both overlooked and probably should have noticed almost immediately. Though the crinoid was "new" to science, it was abnormal and could not be used as a type specimen. We were both disappointed. I left the specimen with Harrell hoping that he could find a use for it someday.

Allen Graffham, Box 996, Ardmore, Oklahoma--One of the stories I like to tell about things that happened while Harrell was working for me, involved a trip to collect crinoids from a quarry in Tennessee. The crinoids occurred on a very narrow ledge at the top of a 50 foot cliff that was left in the quarrying years ago. Harrell had visited the quarry once before and told me it would be hard to work. That was the understatement of the year. First we climbed to the top of the hill above the quarry and came to a very steep bank of clay overlooking the quarry. There was a rather small tree at the bottom of the clay bank and on the lip of the quarry. The trick was, according to Harrell, to slide down the bank and end up straddling the tree and then swing around holding onto the tree and wind up on the ledge. If you missed the tree it was a 50 foot fall with a sudden stop at the bottom. We managed to get down safely but frightened. About that time I started wondering how we would get back up the bank. After digging most of the day on the precarious ledge we dug foot holds up the clay bank and made out way back to the car. We did find some nice crinoids, but I have never gone back to this locality. I have wondered several times what would have happened if we had lost our geology picks while working the ledge. I guess we would still be there. This locality was a tribute to Harrell's fantastic love for crinoids.

B. L. Stinchcomb, Department of Geology, St. Louis Community College at Florissant Valley--With regard to. . . Harold Strimple I might relate the following which took place mid-February 1978. Harold had been sent specimens of a mystery fossil found near the hamlet of Elvins, part of the southeastern Missouri old lead belt. Those cognizant with Cambrian trilobites may recognize the town's name "immortalized" in such genera as Elvinia and Elvinella. Elvins is a small Ozark community located on Cambrian outcrops at the edge of Precambrian crystallines from which a number of creeks flow into Flat River which runs through town. It's from these creeks that the above mentioned trilobites have been collected. Perhaps the trilobites bearing the town's namesake would be sufficient to put Elvins on the map geologically; however, other outcrops in the area yielded a variety of paleontologic enigmas, a characteristic which seems to be frequent in Cambrian Ozark strata.

Harrell was particularly interested in one fossil which had been sent by Bill Jeffries of St. Louis. This was definitely an echinoderm but Bill and others had thought it a Cambrian horn coral. Harold drove down from Iowa City one cold, blustery February day to St. Louis; we then drove south to Elvins with a large wheel barrow, with which to haul out some of the fossiliferous clay. We filled the wheelbarrow; I remember negotiating it along the railroad grade, lowering it over railroad ties then dumping the load of clay into the trunk of Harrell's car. We made about three trips until the rear of Harrell's car literally sat on the axle. We then drove to a local hamburger and chicken emporium and talked fossils, I'm sure to the dismay of local inhabitants whose overhearing of time spans of hundreds of millions of years, conflicted with the accepted six thousand year old earth that they believed in. Harrel and Christina washed the 600+ pounds of weathered shale extracting more of the mysterious echinoderms, but also a variety of minute, nearly perfectly small complete trilobites. (See Journal of Paleontology, No. 1 V. 57 pg. 93). Parts of an unidentified carpoid? also turned up as well as other knowns and unknowns. A year later Harrell returned for another load and we repeated the performance, rear end sagging and tires bulging on the return trip to Iowa City.

Out of this before too long in the Journal of Paleontology should come an article on this peculiar "coral like" echinoderm, by Strimple and Sprinkle.

Amel Priest, Peru, Iowa--Harrell Crinoidal Strimple--My first recollection of Harrell Strimple was in going up to the old geology building at Iowa City, taking some crinoids I had found at Oskaloosa and Pella in the Pella marl. Had one nice calyx specimen and he said I've never seen one like that, can I keep it? Sure. In showing me some of the material he had found in the marl, there were some scraps of an edrioaster. He told me he had sent in some of the best pieces for examination, but the report came back "too fragmented for identification". So I told him I had about four complete ones at home. "Oh," he said, "I'd like to see them." So that gave me an excuse to go back to Iowa City and perhaps view some of the wonderful specimens in the repository. On seeing the edrios, he said "Good night, I can describe them myself," and he did, giving it my name Discocystes priesti.

A trip I got a terrific bang out of was right in Harrell's back yard, so to speak. He had showed me a crown found in one of the local quarries near Iowa City. I asked him, "are you gonna take me out there?" and he said "Sure!" So next time I went over I went early and we went out to the quarry but didn't turn up anything. So I said I'd had better luck on Coralville Dam than this. He said he had never found anything there but we could look. On the downriver side of the dam I found a cystoid with holdfast in place. He said he'd like to have it for the repository, OK. Crossing over top of dam we were about 1-- yard apart and I heard him say "good night". I knew something was up, so I went fast over there. You know what? a nest of Melocrinites crowns. We found several good chunks in the rip rap. The crowns had stems attached. The arms had that parallel double arm effect or look. Some find! I got quite a kick out of kidding him about how poor the collecting was on Coralville Dam.

William T. Watkins, 223 Lyric Dr., San Antonio, Texas--I'm sending, with this letter, something that Harrell Strimple persuaded me to write. I collected the crinoids for, and our names appear together on, a publication Carboniferous Crinoids of Texas with Stratigraphic Implications, 1969. Harrell asked me to write an account of collecting the crinoids at Lemons Bluff on Rough Creek and send it to be published in the Digest, and an account of collecting all of the crinoids in the publication (there are 41) and sending it to him. I divided the account into four parts . . . and had written 3 of them when I got news of his death. I quit writing then. . .

Harrell won't be by to suggest what to do with them this time.

Say I do miss Harrell so much. I became acquainted with him way back in 1954 when he lived in Bartlesville and worked for Phillips Petroleum Company. I visited in his home and we collected together. He had no car then or for several years after that. We'd meet in Ada, Oklahoma or in Ardmore, and we'd collect together. We were very close. He described all new species of crinoids I sent him, sometimes on a co-author basis. If it wasn't for the correspondence with him that I filed away, I couldn't be writing my memoirs with such detail. (Ed. comment--In the fall issues of the Digest you will read these fascinating memoirs.)

Sharon Powell and Kathleen Morner, 1018 Chicago Avenue, Oak Park, Illinois--We will always remember Harrell Strimple saying, "Fossils will never let you down." The first time we encountered him was at the MAPS EXPO II in 1980 where that observation was the basic theme of his talk to the gathering. We were surprised that a person of such vast knowledge and prolific scientific writing had such a wonderfully simple outlook on fossils and was so willing to share his knowledge and also his joy with amateurs as well as professionals.

The next encounter with Harrell strimple came when we visited him and his wife Christina later that year at their home in Iowa City. We had written to them before leaving on a fossil-collecting trip in their area, and they enthusiastically invited us to stop and see them on the way back to Chicago. We did and found ourselves immersed in a wonderful day of looking at Christina's fossils and listening to Harrell recount his experiences with fossils--from his early days of collecting, sleeping in his car, and then hightailing it back to work at dawn Monday morning to his later work with graduate students, trying to instill in them his own excitement and intensity in studying and describing the wonders he found.

When we saw Christina's outstanding collection of Pennsylvanian crinoids--so neat and orderly, each drawer filled with beautiful specimens in little cardboard boxes, many with handwritten slips of paper indicating articles Harrell was still planning to write--it was easy to understand why Harrell might have married her for her fossils, as someone had jokingly told us he had. But Harrell was quick to correct the story. "I had taken so many of her crinoids for research that she felt she had to marry me to get them back!" It was obvious to us that Christina had given Harrell far more than fossils; that she had created an atmosphere in which he could devote himself to his work, by surrendering her dining room table to his books and papers, being always ready to hear about his latest discovery--sometimes debating with him--and spending long hours removing matrix from crinoids so that they could be studied.

During the next two years we saw the Strimples at the MAPS EXPO and exchanged a couple of letters. Then, last June we stopped at Iowa city on our way home from a collecting trip in Oklahoma and New Mexico to visit Harrell and Christina and to show them our finds which included a tiny Allagecrinus bassleri Strimple, a crinoid described in Harrell's first paper and named by Harrell for Dr. R. S. Bassler, who had helped him get started as a researcher. They were as gracious as they had been before and seemed as thrilled with our fossils as we were. Harrell seemed particularly pleased that we had squeezed every minute out of our fossil collecting trip--as he had so often done--heading back to our "other lives" just barely in time.

In our conversations with Harrell and in his letters to us, it was clear that his life had been far from perfect--he experienced the bad luck, hard times, and sad moments that all of us encounter, plus the added frustration of inadequate recognition for the incredible contribution he made to science. But all in all, he was living evidence of the truth of his philosophy, shared at that early MAPS EXPO: The joy of finding fossils and uncovering mysteries as you study them can eclipse the personal and professional problems you encounter in life--"Fossils will never let you down."

The following is a series of articles written exclusively for the MAPS Membership. Several of these articles have appeared in MAPS Digest, beginning October, 1981, Volume 4 Number 9. The last series of articles have not appeared before.

T H E R E S E A R C H C O R N E R -- H. L. Strimple

MOSTLY ABOUT INVERTEBRATE FOSSILS -- Introduction -- Section I

A program of instruction in paleontology is needed for the MAPS membership and after much thought as well as some trepidation I think that a way is possible. It is just not possible to produce all of the basic information and needful illustrations in the Digest so certain existing books are recommended to support articles in the Digest.

There is a basic book that is written in such a manner that anyone can understand what is being said. The book was prepared as an introduction to the study of paleontology. It is not a rehash of older books, even the illustrations are new, and all facets of paleontology are covered, such as plate tectonics, biostratigraphy, feeding mechanism of various creatures, associations, etc. The title is LIFE OF THE PAST by N. Gary Lane, published by Charles E. Merrill Publishing Co., Columbus, Ohio 43216 and it is a paper-back. The price is somewhat less than $14.00 at the bookstore.

For INVERTEBRATE FOSSILS the Moore, Lalicker and Fischer text book published by McGraw-Hill Book Co., New York, remains the best available to date for learning terminology, taxonomy, etc. The next step forward can be INDEX FOSSILS OF NORTH AMERICA, Massachusetts Institute of Technology, Cambridge, Massachusetts. I do not know the current price and in fact it is perhaps better to invest instead in the TREATISE ON INVERTEBRATE PALEONTOLOGY even though that is a major investment. Fortunately the TREATISE is in sections so that one does not have to purchase the entire thing but rather can purchase the sections dealing with the group or groups in which one has a particular interest. A price list can be obtained from the Geological Society of America, 3300 Penrose Place, Boulder, Colorado 80302.

My personal approach to the objective of being helpful in this project will be three-fold: (1) general information and techniques; (2) a guide to the study of fossil echinoderms; (3) insight into current research particularly on echinoderms.

PALEONTOLOGY - A "FLUID" SCIENCE -- Section 2

Paleontology, the study of fossil life, is not an exact science in the sense that mathematics, engineering, physics, astronomy, chemistry are considered to be "exact" sciences. Of course, even some of those disciplines get upset once in awhile when an Einstein comes along, or we send a probe to Jupiter. In some respects the study of fossils is an art and one has to have a "feel" for it. It is said that when three specialists on a group of fossils get together there are apt to be four opinions about any given problem. For obvious reasons this is not the face shown to the public or to students, and, in fact, it is not as chaotic as it sounds, but rather it is a healthy condition. The professor who teaches what he learned 20 years ago will soon find that he has no students in his course. In my 19 years at the University of Iowa I never worked with a graduate student who did not know more about geology than I, but we learned more together.

There is seldom a month that passes without one or more studies appearing somewhere in the world which deals with fossil echinoderms. The TREATISE crinoid volumes were out of date even before we dotted the last "i" and crossed the last "t." I am acutely aware of this condition which is why I have never attempted to prepare a basic instruction course. One must ignore exceptions and problems in order to make a nice package with which to teach, and I just cannot do this.

Several years ago I set up a seminar and had a famous crinoid investigator present the phylogeny (evolution) of camerate crinoids. It was a beautiful presentation with thecal diagrams, etc. Very convincing except that I personally knew about 50% of it just did not work.

People bring a specimen to me at a meeting and are often surprised when I will not give a name for it. I might have some idea of a name but may also have a memory that it has been changed. With camerates one has to work out the relationship between plates, how the theca is put together, along with other factors. The most common Burlington camerate crinoid is Dizygocrinus rotundus which, however, is now known as Azygocrinus rotundus (changed by Lane). Among the inadunates, for example, there is a common little Ordovician crinoid Heterocrinus heterodactylus from the Cincinnati, Ohio, area so called even in the TREATISE; however, it is now Cincinnaticrinus varibrachialus* Warn and Strimple (1977). Heterocrinus heterodactylus is no longer an acceptable name for the species or for the genus either, for that matter, for the Cincinnati specimens. Sorry about that.

For practical purposes one does have to memorize a great amount of information and can even learn to identify species, on sight as it were, but only to the level of their source of information. One can implant the image of a picture, say of Phanocrinus formosus, in their mind and then recognize a specimen when they see it. However, unless one understands why or what morphologic features cause it to be so named, they can easily misidentify something that looks like Phanocrinus formosus but is actually another species. I should not even mention the species really because Phanocrinus and the kindred Pentaramicrinus are probably the most common of all Chesterian (Upper Mississippian) crinoids and I do not mind telling you they have mighty near put me "around the bend." After many attempts through the years I am still uneasy about some of the present interpretations or concepts. Unlike some investigators, I worry about my own as much as I do about someone else's concepts.

Perhaps what I am attempting to convey is that one must use reasoning in this as well as in almost any other endeavor.

*Note -- Warn, John and Strimple, H. L. 1977. The disparid inadunate superfamilies Homocrinacea and Cincinnaticrinacea (Echinodermata: Crinoidea), Ordovician-Silurian, North America: Bull. Amer. Paleontology v. 72 18 pls. This study includes updated stratigraphic information, locality data and a thorough study of the small disparid crinoids. It is published by the Paleontological Research Institution, Ithaca, New York 14850, and I believe the price is under $7.50. It is primarily the Ph.D. dissertation of John Warn at the University of Cincinnati under Dr. Kenneth Caster.

MOSTLY ABOUT INVERTEBRATE FOSSILS -- Results of Cooperation -- Section 3

Science, like society, is made up of individuals and each individual is unique. The *basic* drive and motivation is different for each individual. The point is that all of the strengths and weaknesses of human nature are present in the scientific community just as they are in the general population. Individual egos often override "good sense", teams are organized to compete with other teams dealing with the same subject, frustration takes place and can lead to "cheating" etc. But cooperation can have far reaching effects, and some examples are given here.

There is a quarry in the Lawrence Uplift (an eastward extension of the Arbuckle Mountain uplift of Pontotoc County, Oklahoma) where a thin layer containing rare echinoderm specimens are preserved. The formation is the Bromide Formation (Blackriveran, Ordovician) and a few small spoil heaps remain. A massive study of the echinoderms of the Bromide is underway by a team of specialists led by Dr. James Sprinkle, University Texas, Austin, Texas. The massive collecting efforts which have been done in the past leading up to this point make a long story which will not be discussed. I am not a member of the team by choice, primarily because my interests in the Ordovician are much wider and extend from western Virginia across the south into Oklahoma, north into Missouri, Iowa, and Minnesota. Dr. Dennis Kolata (Illinois State Geological Survey) has already covered the Ordovician of Illinois and Wisconsin.

Christina (my wife) and I collect in Oklahoma once or twice a year and usually make the quarry in Pontotoc County. A couple of years back I found a couple of strange, small fragmentary specimens which I could not identify and Christina found an absolutely exquisite specimen of the incredibly rare diploporite cystoid Eumorphocystis multiporata. We were attending the IX International Carboniferous Congress in Champaign-Urbana, Illinois, and took them along. It turned out that Sprinkle had plenty of specimens of the diploporite but the "scraps" I brought along showed some features he needed for the study. In the fall of 1980 we collected there again and Christina found a good portion of an eocrinoid which I had never seen before. I went back to the pile where she had found it and found a smaller one. We sent them down to Sprinkle, and he was really excited. Christina's specimen showed details of the summit or oral area (very important in identification) which were obscure in other specimens. In addition Sprinkle had another partial specimen which fit perfectly onto the lower part of Christina's specimen. The combination of the two provides a nearly whole specimen which will be the holotype of the new species and in turn the type species of a new genus. As a matter of fact he had to redo his plate and manuscript. My specimen became a paratype.

A thorough investigator can often learn more about an animal from partial or incomplete specimens than he can from apparently perfect spectacular specimens. This does not mean that the complete specimen is not also needed for a comprehensive study and understanding of a species. There is a tendency for collectors and in particular commercial or semi-commercial ones to go for large spectacular specimens and ignore small specimens even though the small ones are commonly better preserved. Many species never get very large, in fact there are even micro-crinoids (less than 0.5mm) which are largely ignored by professionals as well as amateurs. With the advent of the scanning electron microscope (SEM) there is some current activity in the microcrioid field primarily by N. Gary Lane (Indiana University) and George Sevastopulo (University of Dublin, Ireland). Yurry Arendt (Moscow, Russia) has contributed heavily to the studies (without the SEM) and Prokof in Czechoslovakia has published a little. I have been involved for years to some degree. We exchange some ideas and some specimens on occasion. Microcrinoids are now known to range from lower mid-Ordovician to Triassic although the documentation is rather sketchy in places. When Gary Lane was here at our home recently we spent some time discussing various aspects of microcrinoid studies and looked at many specimens from various places and horizons. This is virtually a new frontier of study albeit very tedius and difficult work. A good binocular microscope is almost a prerequisite to pick the specimens from washed residues. The rewards can be great, in my opinion, and many life forms recovered in addition to crinoids.

There has been some controversy over whether the microcrinoid Tytthocrinus has two or three circlets of plates in the theca. Christina picked hundreds of microcrinoids from residue we collected on the flank of Apache Hill, Lake Valley, New Mexico, from a marl in the Nunn member, Lake Valley Formation (Mississippian) and a considerable number were Tytthocrinus which is a small form even among small microcrinoids. N. Gary Lane decided to study some of the better specimens with the aid of the SEM and so resolve the problem for all times. If there are only two circlets of plates the form is probably synonomous with Octocrinus which has in fact already been suggested. There will be more cooperation later.

MOSTLY ABOUT INVERTEBRATE FOSSILS -- Recommended Steps In Identification of a Crinoid-- Section 4

A. First phase
   I. Is the crinoid an inadunate, camerate or flexible?

      a. Most camerate (Camerata) crinoids have a rigid theca (calyx plus tegmen). The cup is usually joined with fixed brachials (arm segments and/or interbrachials to form a calys. Unfortunately there are camerate crinoids which mimic inadunate crinoids (e.g. Dichocrinus) and you have to learn how to distinguish them.

         1. Another major division is based on whether the cup is monocyclic (composed of basals and radials) or dicyclic (composed of infrabasals, basals and radials).

      b. Flexible (Flexibilia) crinoids are usually most readily identified as such by the uneven suture between brachials (arm segments), sort of like a tongue and groove called a "patelloid process." There are other criteria but rather complicated. It

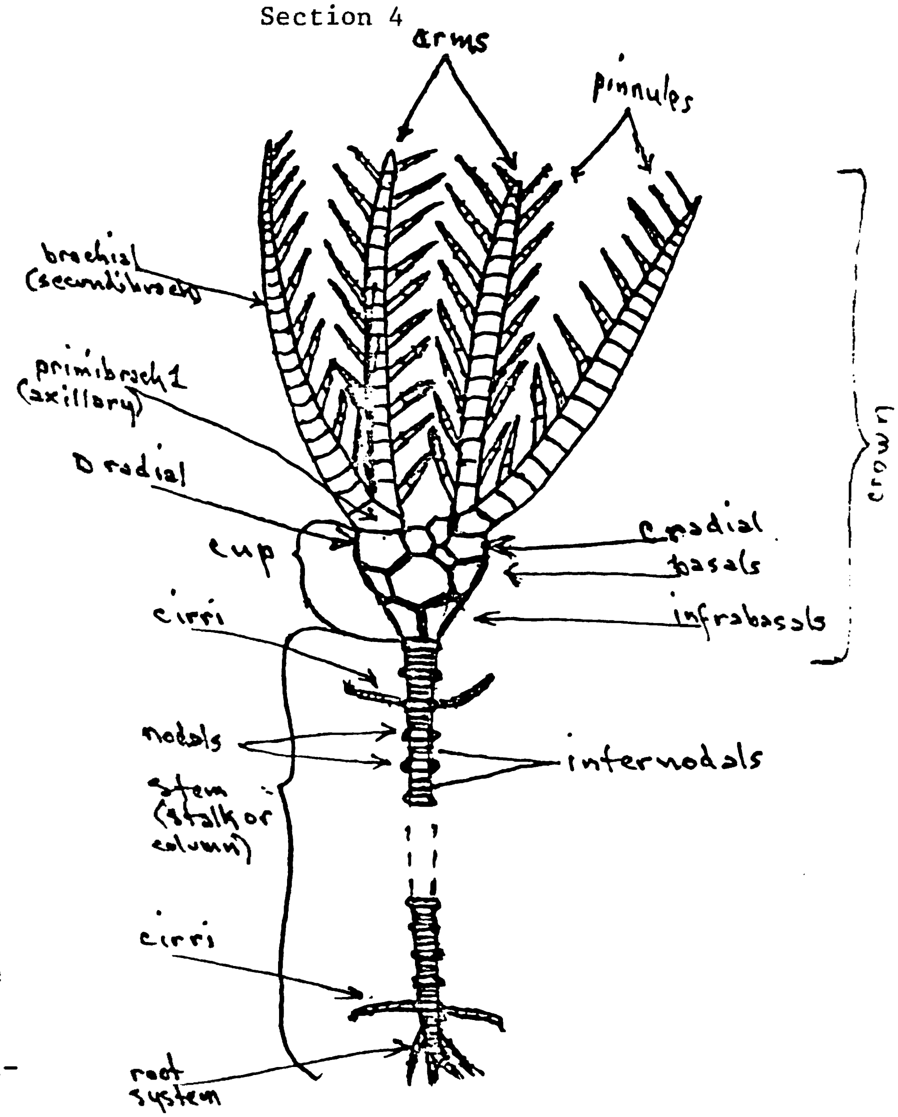

Fig. 1. Rough drawing of a dicyclic inadunate crinoid illustrating various parts.

is relatively easy to develop a "feel" for the group as a whole But some groups mimic inadunate crinoids in some respects.

c. Inadunates (Inadunata) commonly have a more simplified structure than the other two major groups but their simplicity only makes it more difficult to properly classify them.

   1. A major division is made on whether the cup is monocylic or dicyclic. A new problem has arisen in this regard in that it has been found some dicyclic crinoids have lost or discarded their infrabasal circlet and have thus become pseudomonocyclic. This was first reported by Warn* (1975) and it is difficult to judge at this time how much effect it will eventually have on existing schemes of classification.

The above represents the mental steps which I usually take when I see a crinoid for the first time. There is much more to come but most people are unable and/or unwilling to assimilate too much information at one time. Perhaps what has been written here will be helpful. It is suggested the reader look at specimens or whatever books they have at hand and see whether it makes sense to them. I don't know how effective this series of instruction will be but can make a suggestion for anyone who is seriously interested in crinoids. Both my wife and I are retired. Christina has an extensive collection of crinoids and most any crinoid lover is welcome to come see them and learn about them. She will even trade if you have a crinoid that she would like to add to her collection, but it will be her choice.

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*Reference - Warn, M. J., 1975. Monocyclism vs Dicyclism: a primary schism in crinoid phylogeny? in Studies in Paleontology and Stratigraphy. Bulletin American Paleontology, vol. 67 (287), pp. 421-441.

HOW GOOD IS YOUR ATTENTION SPAN?
A "test" on how to interpret the crinoid sho wn in Figure 1. Answers below.

1. Is the crinoid an inadunate, camerate or flexible?
2. Is the cup dicyclic or monocyclic?
3. Is the cup conical, globose, bowl-shaped?
4. Are the infrabasals upflared, subhorizontal or downflared?
5. Are the arms pinnulate or non-pinnulate, uniserial or biserial, short, medium or long:
6. How many arms, where do they branch?
7. How many extra plates (anal plates) in posterior (CD) interray?
8. Do primibrachs 1 fill upper surface of radials?
9. Is the stem round, pentagonal, quinquelobate?

The crinoid sketch is a figment of my imagination but if it were a specimen I would, by this point, judge it to perhaps belong to the genus Hypselocrinus Kirk and would start checking among species of about Keokuk age. Actually, the cup shape is much like that of Scytalocrinus sasabensis Moore & Plummer from the Atokan (Middle Pennsylvanian) of the Llano Uplift in north central Texas which, however, is probably not a bonafide Scytalocrinus and is a small form with more delicate somewhat shorter arms than found in my sketch.

Remember that no one has said this was going to be easy but, eventually, one builds up a "memory bank."

ANSWERS TO "TEST" above: (1) inadunate; (2) dicyclic; (3) tall and conical; (4) upflared; prominent; (5) pinnulate, uniserial, medium; (6) ten arms indicated, branching on primibrachs 1 where visible; (7) three; (8) yes; (9) appears to be round.

MOSTLY ABOUT INVERTEBRATE FOSSILS -- The Concept of Pentameral Symmetry -- Section 5

Crinoids are said to reflect pentameral symmetry and in a broad sense this may be true, that is, there may be five infrabasals, five radials, five orals, five arms, or multiples of five (commonly), etc., but true symmetry is rare. In the drawing of an inadunate crinoid which I prepared, the symmetry is broken by three small anal plates in the cup between C and D radials which is known as the CD interray (the basal plate is CD Basal) and/or the posterior interray. In orienting a specimen the posterior interray is toward the viewer and the opposite side is the anterior or A ray. Clockwise the ray to the right of A is B ray and so around the clock to C-D and E (which is to the left of A ray). In the not too distant past the rays to the right were called "right anterior"; to the left they were called "left anterior." But back to the symmetry problem.

Among the camerate crinoids, particularly the monocyclic ones, the lower-most or proximal circlet of cup plates (which in the case of monocyclic are basals) form a hexagon rather than a pentagon. This is to accommodate an element called a primanal located in the posterior interadius. The primanal is very similar in appearance to radial plates except it does not support any arms but instead may support an anal opening or a small anal tube. The basal circlet may have two to five basals or even a single element in rare instances of total fusion.

There are a considerable number of crinoids which favor three infrabasals rather than five. Another trend toward triameral conditions is exhibited by some forms with rather long first brachials (axillary primibrachs 1). Often these elements in the C, d, and A rays are longer than the same elements in B and E rays This condition is readily observed in young specimens of Apographiocrinus and Erisocrinus of Pennsylanian age (see Strimple, 1938). This was one of my earliest scientific observations and there has been nothing to discount it to date. To carry the idea further it is my belief that many inadunates (probably not all) have arms which are "mirror pairs," that is, C and D are the "primary rays" and are paired, A ray is probably next which creates a "triameral condition" and the pair B and E are perhaps branches off the C D ambulacral system. In species or genera where certain rays cease to bear arms (e.g., Indocrinus or Tribrachiocrinus) it is usually the "weak" pair (B and E) in which the arms cease to develop.

Perhaps the most telling blow against the concept of pentameral symmetry is afforded by Calceocrinidae. This major group of inadunate crinoids flourished from Ordovician into Asagean (mid-Mississippian, or Lower Carboniferous) time and exhibit dramatic asymmetry.

Pentameral symmetry is a fine general concept which can be applied to echinoderms in general as long as one realizes it is not universal. There actually are some fossil crinoids which display true pentameral symmetry. A few that come to mind are the camerate crinoid Maquoketacrinus and among the inadunates Erisocrinus, Pontotococrinus, the strange Cupressocrinites, Encrinus and a few others, but they are rare.

Remarks. I have not attempted to document (or give specific references) to all statements or observations because that would create unwieldy reference lists. Most of what I have said or will say can be found in the literature but is not necessarily easy to find or without controversy. Some will be personal observation, as I usually note at the time. I could not resist the opportunity to give reference here to an "original observation" made back in 1938.

Reference Strimple, H. L., 1938. A group of crinoids from the Pennsylvanian of northeastern Oklahoma: Bartlesville, Oklahoma: 14 p.

THE ARMS OF CRINOIDS -- Section 6

Most crinoids have arms and each arm (whether branched or unbranched), together with the radial plate of the cup is called a ray. Those which do not have arms are called a brachiate, are very small, and probably fed with non-skeletal podia. Individual segments are called brachials. The lowermost segments are called primibrachals or primibrachs. If an arm befurcates (or divides) on the first brachial, then that element is called an exillary primibrach 1 and the next series of brachials are secundibrachs. There are variants of these designations but once you understand the principle involved, they are not difficult to follow. For simplification some authors use symbols like PBr 1 for primibrach 1, but usually they designate what symbols are used the first time they appear in the study.

When the brachials are in a line and have horizontal sutures, they are termed uniserial. When the sutures between the segments are oblique (sort of wedge shaped), they are called cuneate or cuneiform. When the brachials interlock, they may be inequibiserial or equibiserial.

If all arms divide equally, they are said to be isotomous. If divisions are not equal, they are heterotomous. The first division is commonly isotomous but often subsequent divisions are from the outside rays inward (endotomous) or inside rays outward (exotomous).

I have not checked on the potential number of arms that might be found but know some pirascrinids (Inadunata) have as many as 80 arms at their tips.

Some primitive inadunate crinoids only bear five arms (which are commonly non-pinnulate). For many years I considered any crinoid which had five arms to be "primitive," or more primitive than related forms. This created some problems with lineages. For example, Cromocrinus Trautschold in the Myachkovian (MoscoOvian) of Russia has five arms. The age is about equivalent to Middle Pennsylvanian of North America. There is a possibility that Cromyocrinus evolved from an older form like Ureocrinus, Wright & Strimple, but neither genus is "primitive" and both occur with ten armed relatives. It is tempting to say that a five armed condition is inefficient but Synbathocrinus with five non-pinnulate arms, together with its derivative Taidocrinus, persists from Devonian to Permian time. It does have a small cup as compared to Cromyocrinus but not too much smaller than the cups of Ureocrinus. Very likely it is a divergent trend which became a specialization that takes place in some lineages. The arms of Cromyocrinus are quite thick, are very long and the pinnules are large. Curiously enough, some cromyocrinids add arms, that is, develop more than ten arms (e.g., Parulocrinus, Probletocrinus).

In some crinoids there are no pinnules on the arms (e.g., all flexibles). In most crinoids each brachial bears a single pinule alternating with the one below or above. Individual segments are called pinnulars. Pinnules and brachials bear podia, fleshy elements which expand from fluid carried in by the "water vascular system." They contract by sending the water back. The podia bear hair-like sensory devices which send a signal when touched and cause the podia to react. A mucous-like substance secreted by the podia serves to capture the microscopic food (large minute algae, ostrocodes, etc.). The food is carried down the ambulacral canals located on the inside of the arms or pinnules to the mouth and on into the gut. Podia also act as respiratory devices in the exchange of carbon dioxide for oxygen. Remember from statements above they are conneted with the water vascular system for expansion and contraction, that is, water rich in carbon dioxide comes from the region occupied by the organs in the theca, in the process of expansion gas exchange takes place and the oxygen enriched water returns to areas where the vital organs are located (coelomic cavity). There are also other methods or points of gas exchange (respiration).

Food (microscopic) is captured from the surrounding water, therefore, crinoids are called mucous filter feeders. The arms and pinnules often form feeding fans for this purpose.

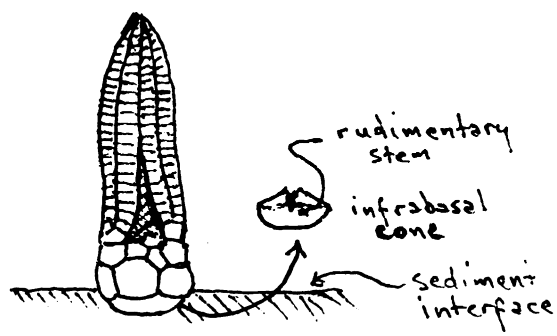
In fossil crinoids the mouth is commonly covered by the tegmen and often the covered ambulacral (food grooves) of the tegmen are easy to distinguish on the tegmen particularly in camerate crinoids. The ambulacral tracts or grooves of the arms or armlets (flexible crinoids do not have pinnules but many have armlets) often have covering plates but it is not proven that all crinoids have such elements which, however, might be a matter of preservation or lack of preservation.

Arms are admittedly somewhat variable in a great number of species or even in some lineages which has caused some investigators to consider them to be too unstable to be useful in phylogenetic (evolutionary) study. As a matter of fact, in my opinion, the arms are remarkably stable in many, if not most species, as well as in higher taxon (genera, families, etc). Certainly some variability takes place and there are commonly transitional forms when almost any morphologic change takes place. In addition, we seldom have a large enough population, that is, specimens of any given species from one horizon and exposure to judge the range of variability and/or aberrations that might normally be expected for any given species.

ANATOMY OF A CRINOID STUDY -- Section 7 --

It has been my intention to provide first hand accounts of various fossil studies with emphasis on methodology and current status of activities. In the September, 1982, issue of Journal Paleontology (vol. 56, p. 1133-1137, pl. 1) I had a small paper dealing with the species Agassizocinus dissimilis Weller (1920). The main purpose of this study was to document three well preserved specimens which probably from the type locality (the exposure from which the type specimens used in the description of the species were collected) of the species and to link the species with less well preserved specimens from other geographic areas. The type area is in St. Clair County, Illinois (the Illinois Basin), one area is in Madison County, Alabama (the Southern Appalachian Mountains), and the other in Craig County, Oklahoma (the flanks of the Ozark Mountains).

This small study is only one among many dealing with the genus Agassizocinus which is, for several reasons, one of the more interesting and challenging inadunate crinoids of Chesteran (late Mississippian) time. The fused stemless infrabasal cone is a thick solid element that is virtually indestructable so that specimens are preserved wherever the genus lived and it was prolific as well as widely distributed in North America. Complete cups are rare and complete crowns even more so although Ettensohn (1974, Journal Paleontology, vol. 49 1041-1061) has reported the occurrence of numerous well preserved crowns from eastern Kentucky which he identified as Agassizocrinus lobatus Springer (1920). However, in my opinion they do not appear to be conspecific with that species. A. lobatus was described on the basis of distinctive (lobate) infrabasal cones from lower Gasperian strata in the Monteagle Formation of Madison County, Alabama. Burdick and Strimple (19) considered A. lobatus to be conspecific with A. occidentalis however after re-examination of the holotype of that species I have concluded the two forms are not conspecific. Even though a complete cup of A. lobates has not as yet been found, I believe it to be a valid species. Now there is a project for the collectors in the southern Appalachians, please examine your specimens to see whether you might have a bona fide A. lobatus and keep your eyes peeled when you are in the field. Former MAPS member Richard Keyes has found a few infrabasal cones which belong to the species and I have them here under study. As a matter of fact I would like to see any cups or crowns (cups with arms attached) of Agassizocrinus from anywhere provided there is adequate documentation of the location where they were found.



Sketch of a crown (cup plus arms) of the eleutherozoic (free, or stemless) inadunate crinoid Agassizocrinus dissimilis in position on the sea floor (restored). The five infrabasals are anchylosed, or fused, into a single unit (infrabasal cone) and have overgrown the remnant of the stem.

There is a certain amount of variability within any given species so that the cautious investigator is forced to decide what degree of variation is allowable. In modern living species the basic criterion is whether they effectively interbreed or do not. With fossils we must depend on the morphological features of the preserved endoskeleton. Those who are ultraconservative are known as "lumpers" and a lessor amount of effort on the part of the investigator is required to follow this course. In practice when a "lumper" is working with a large genus group, the tendency is to suppress (synonomize) previously described species but conversely to propose new taxa (species) based on their own material. The other side of the coin is the "splitter" who commonly becomes more immersed in the study and recognizes subtle differences which may be very difficult to substantiate to the satisfaction of other investigators. Obviously the most desireable approach is somewhere in between. In the recent study dealing with A. dissimilis I was conservative and as I examine my illustrations the uneasy feeling of having been too conservative pervades me. There are differences between the specimens albeit not major ones. Considerable more investigation needs to be done on the genus and in fact is under way.

I have at hand a collection of juvenile infrabasal cones from a very restricted area (about one yard long and half a yard wide) in Craig County, Oklahoma which was called to my attention by MAPS member Claude Bronaugh, who is my oldest friend and colleague. Not only did he bring the matter to my attention he also gave me the specimens for study. Together with my good wife Christina we have managed to recover about 300 cones and one partial cup. A by-product of the effort has been a large collection of the strange coral Palaecis which is under study by a Canadian investigator, Alan McGwyan, of this type of coral. Really small specimens of Agassizocrinus are virtually unknown although Ettensohn (1975) reported one small specimen. At present it is my belief the small pocket from Craig County represents a "nursery" of sorts and that the specimens dispersed after they attained sufficient strength in their arms to assist in moving with the currents. In lacking a stem they are free to move and there are no large (mature) associated cones although there is a considerable range in size within the juveniles present. Some modern comatulids (stemless crinoids) are known to move by pulling themselves along with some of their arms and as well by swimming for short distances. Growth stages are termed ontogeny and there is a law of Wachsmuth and Springer "ontogeny recapitulates phylogeny." In other words, the young of one species will display characteristics of its progenetor. In the case of Agassizocrinus the ancestor no doubt possessed five discrete infrabasals and a stem but the youngest (smallest) specimen in the group at hand neither has a stem or divided infrabasals. There is a depression at the point of attachment for a stem but no markings (cicatrix) for a juncture. A stem is known to have existed in larval stages of Agassizocrinus, just as one does in modern comatulids which are stemless in maturity, and in fact the rudimentary remnants of the stem are often found within the cone itself. The previously mentioned juvenile specimen of Agassizocrinus reported by Ettensohn does have a short segment of stem attached and retains sutures between infrabasals which is somewhat perplexing in light of my unrecorded material. In any event we are still looking for the predecessor of Agassizocrinus.

Another important collection of Agassizocrinus under study is from Chesteran rocks of Chainman Mountains of the far west. These are all infrabasal cones save one juvenile which has some basal plates attached. The first and best preserved specimens known to me were donated by an Iowa alumnus Dwayne Stone, a professor at Marietta College and also a MAPS member. Subsequently large collections from the same area were obtained from another Iowa alumnus, Claude Spinosa, a professor at Boise State College, Boise, Idaho, and from N. Gary Lane, a colleague and MAPS member/contributing professional writer.

Not mentioned previously were specimens contributed to the Agassizocrinus dissimilis study by MAPS members Al Hartman and Claude Bronaugh, or a report on A. patulus Strimple from Arkansas co-authored by MAPS member Craig Brown. There is much that has not been discussed. The genus was proposed back in 1875 by Owen and Shumard so obviously it has received attention for a considerable period of time. One might think that to be plenty of time to resolve all problems but the study of fossils is an ongoing process subject to new material, new information, new interpretations.

This account demonstrates the pattern of interaction which I have personally developed and enjoyed through the years, that is, cooperation between professionals and collectors. It is not difficult to envision the boon to our science which more of this type of interaction could stimulate.

THE ANAL PLATES OF CRINOIDS -- Section 8

There has been considerable attention devoted to plates located in the posterior (CD) interray commonly referred to as anal plates. To date there has been no concensus of opinion concerning the origin of these extra plates and indeed it is almost certain that more than one mode of development is involved depending on the lineages.

The late R. C. Moore, in an effort to create common terms, proposed that the lowermost plate in the cup above CD basal be termed the primanal for all crinoids. The area does appear to uniformly mark the passage of the hind gut toward the anus and the proposal was accepted by those of us present. Among the inadunates with more than one anal plate this means the element called a radianal became the primanal whereas when only one plate was present which might represent anal X rather than radianal it also became the primanal. The term primanal was actually used in the broad context for several months, as in a major study by Moore & Strimple in 1973.

However, George Ubaghs of Liege, Belgium, who was also a major author of the Treatise challenged the general usage of primal because the lowermost "extra" plate in CD interray in a camerate crinoid was not identical to the radianal plate of an inadunate crinoid and convinced R. C. Moore, editor of the Treatise, to restrict the term primanal to camerate crinoids. There was never any question about the origin of the plate.

In Section 5 I mentioned the primanal of camerate crinoids which in some lineages is not much different from a radial plate. In the present Section the anal plates of inadunate and flexible crinoids will be discussed.

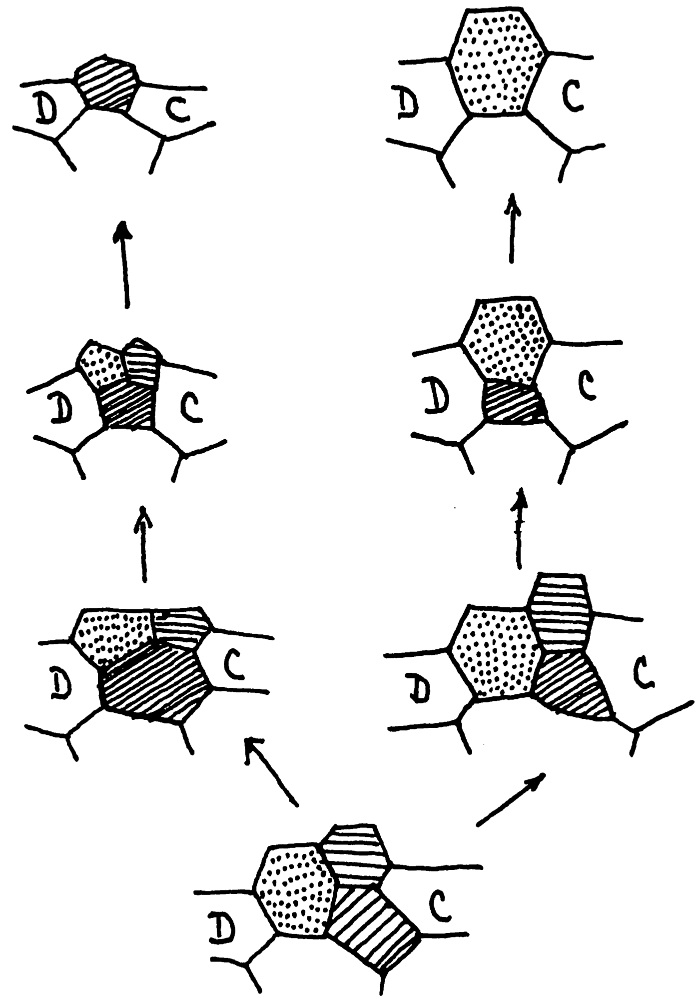


Figure 2. Sketches of the posterior (CD) inter ray as found in selected individual Late Paleo zoic inadunate crinoids. No two individuals belong to the same genus. Those to the left demonstrate migration of anal plates in which the radianal is the last remaining in the cup; tc the right the radianal is resorbed and anal X is the last remaining in the cup. Letters represent position of radials; diagonal lines the radianal (RA); horizontal lines the right tube plate (RX); stippling the anal X.

The Order Disparida (monocyclic inadunates) is characterized as having simple cups and crowns, nonpinnulate arms, prominent radial and oral plates. Asymmetry which is expressed as "bilateral symmetry in different rays" is common, is almost universal in the order. Pentameral symmetry is attained in a few genera (examples, Taidocrinus Tolmochev, Pygmaeocrinus Bouska, Metallagecrinus Strimple). Although the cups are simple they are also complicated because of compound radials which are a common feature in chronologically older (primitive) genera. A compound radial is one which is horizontally divided with the distal (upper) section called a superradial and bearing the arm. One scenario for the origin of the radianal (RA) plate is that it represents the lower radial (inferradial) which has migrated from the C ray into the CD interray. In my opinion such migration does take place in some lineages but it does not follow that it applies to all inadunate crinoids. For example, in the little Ordovician genus Eustenocrinus *Ulrich there are* compound radials in all five rays, primibrachs 1 are nonaxillary and are said to be "fixed", what would normally be the C ray arm has been captured by the hind gut and serves as an anal tube so that primibrach 1 has become anal X in the C ray.

The Order Cladida (dicyclic inadunates) includes a varied assortment of crinoids. The Suborder Cyathocrinina includes forms having five to no anal plates in the cup (rarely more than three). When more than three anal plates it is rather obviously due to a widening of the posterior interradius and incorporation of tegmen plates in the cup. At least the cladids are not plagued with compound radials, although Carabocrinus of Ordovician age has a compound radianal. In general the cyathocrinines retain a narrow radial articular facet (primibrachs do not fill the upper width of radials).

The Suborder Dendrocininа of the Order Cladida is said to have three to no anal plates. Some primitive forms (e.g. Ottawacrinus, Merocrinus, Cupulocrinus) have what can be termed one or more compound radials. There is only one such element in Merocrinus and it is interpreted as being an inferradial in the Treatise primarily because the anal tube (and anal X) is developed as a half arm above C radial. It might be more correct to interpret the "inferradial" as C radial and the plate above as an axillary primibrach 1. This is a problem I will be forced to face again in the not too distant future in studies under way but am not prepared to consider it further as I write this. It is hard to realize I started to worry over this very thing over 20 years ago while working on Bulletin 100 for the Oklahoma Geological Survey.

Suborder Poteriocrinina has four, three, two, one, or no anal plates in cup. I would like to think of this group as being better understood than most but realize that many unresolved problems remain. Commonly there are three anal plates in "normal" position, that is, the radianal (RA) is in oblique position to the right of anal X, resting on CD basal but in broad contact with BC basal, supporting RX (or right tube plate) above in broad contact with C radial to its upper right (see Section 4, Figure 1). Anal X is directly above CD basal, has broad contact with D radial to the left, RA to the right below and RX to the right, extends slightly above the cup where it bears a single tube plate on its upper surface. RX is directly above RA, contacts C radial to the right, a tube plate above, anal X to the lower left. It extends above the cup and is higher than anal X. I have termed this as "primitive" in conjunction with studies of modifications which take place in late Paleozoic time when evolutionary changes take place which lead from three to no anal plates. A rather rare diverse condition exists in some lineages in which the anal plate does not reach the summit of the cup and an anal tube plate enters the cup producing four anal plates. I have observed this in some species of Agassizocrinus, Intermediacrinus and Cryphiocrinus all of which are late Mississippian in age.

Taxonomic studies would be much simpler if crinoids had just realized how helpful they could have been had they evolved in a straightforward, consistent manner. It is almost perverse the way they actually evolve toward the same end result but sometimes by different routes. It is highly probable the radianal is a basic cup plate, probably the C ray inferradial of older stock and therefore the element

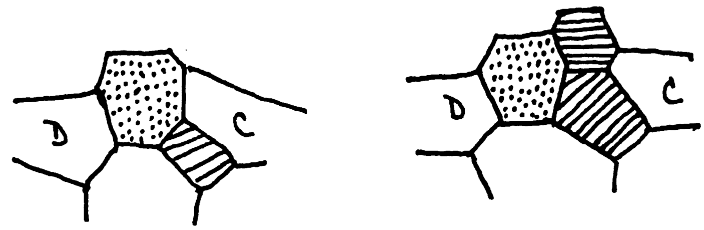
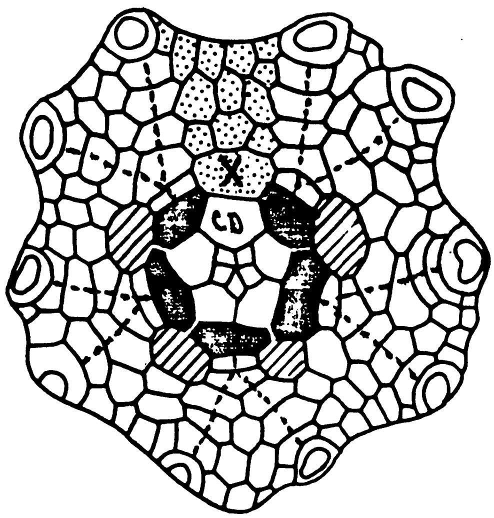


Figure 3. Sketches of anal plates of the posterior (CD) interradius of selected inadunate crinoids. The figure to the left represents a somewhat advanced modification, wherein the RX plate has been eliminated from the cup, if the crinoid is evolved from a form like that on the next page. This not an uncommon situation in late Mississippian or Pennsylvanian time. However, both arrangements coexist in Devonian and earlier time and it is possible that an occasion among these older forms RX migrated from the anal tube down into the cup. The obvious incentive would be to form a broader base of support in the cup itself for the anal sac or tube. In any event I do not consider the two anal plate arrangement to be "advanced" in the older genera.

Many genera of flexible crinoids have a small quadrangular shaped radianal much like that shown in the illustration above.



Anterior (A)

Figure 4. Plate diagram of Cyphocrinus based on C. gorby Miller. Radials black, later interray interprimibrachs lines, CD interray interbrachs dotted (primanal marked X), CD basal marked CD, fixed arms ridged and marked with dashes.

could be expected to remain in the cup so long as an anal plate was retained. In many linages this actually is what happens but unfortunately there are diversities in which the radianal is gradually resorbed and the anal X is the remaining single plate. It is thought that Delocrinus (with one anal plate) evolved Phanocrinus by migration of RX from the cup and resorbtion of RA. In the family Cymbiocrinidae it is certain the radianal migrated to posterior position and the remaining single anal plate is radianal. These matters are documented but would require the listing of several references. I don't remember why my studies of this particular phenomenon did not get included in the Treatise but was probably forgotten in the press of other matters. George Ubaghs was aware of it because he used some of my drawings in another study several years ago, and it probably influenced him in rejecting the use of primanal in inadunate crinoid terminology

The plate diagram of a specimen of Cyphocrinus is illustrated by by Figure 3 and is considered in some detail. It is a dicyclic camerate (infrabasals are present) and has recently been placed in a new family Elpidocrinidae by Frest & Strimple along with some other genera. Because this is a basal view the ray designations are counter clockwise starting with A at the bottom. There are a large number of fixed brachial plates and particularly interbrachials in the calyx. Two primibrachs are present in each ray, the second being axillary. First interprimibrachs are large, commonly followed by two plates in the next range and there may be as many as five at the summit of the calyx. The posterior (CD) interray is readily distinguished in that primanal is in contact with CD basal. The pattern of anal plates is 1-3-3-5. Interbrachs are present between half-rays of the fixed arms. Free arms would attach to the last fixed brachials. Interbrachs join tegmen plates.

When attempting to compare with other forms notice will be taken that five infrabasals, basals and radials are present and that radials are in contact all around except for the posterior interray where a primanal interrupts, first primibrachs are quite large and followed by numerous plates, fixed arms bear a ray or ridge, there are 10 arms and they are well separated all around, in a basal view the primary interrays are depressed. All of these as well as other factors must be taken into account when attempting to identify polyplated camerate crinoids.

If you find something that "sort of looks like" the above in the Burlington Formation, check harder because it is an older (Silurian) genus.

In crinoids of this nature, that is having very small infrabasals, a problem often arises when the proximal columnals of the stem are preserved because the plates may be partially or entirely covered by the stem.

THE STEM (STALK, COLUMN) -- Section 9

In Section 4 a sketch of a complete inadunate crinoid was presented (Figure 1) which included the stem, cirri and holdfast. In this representation the stem was heteromorphic (alternatively expanded columnals) and the holdfast was in the form of a root system.

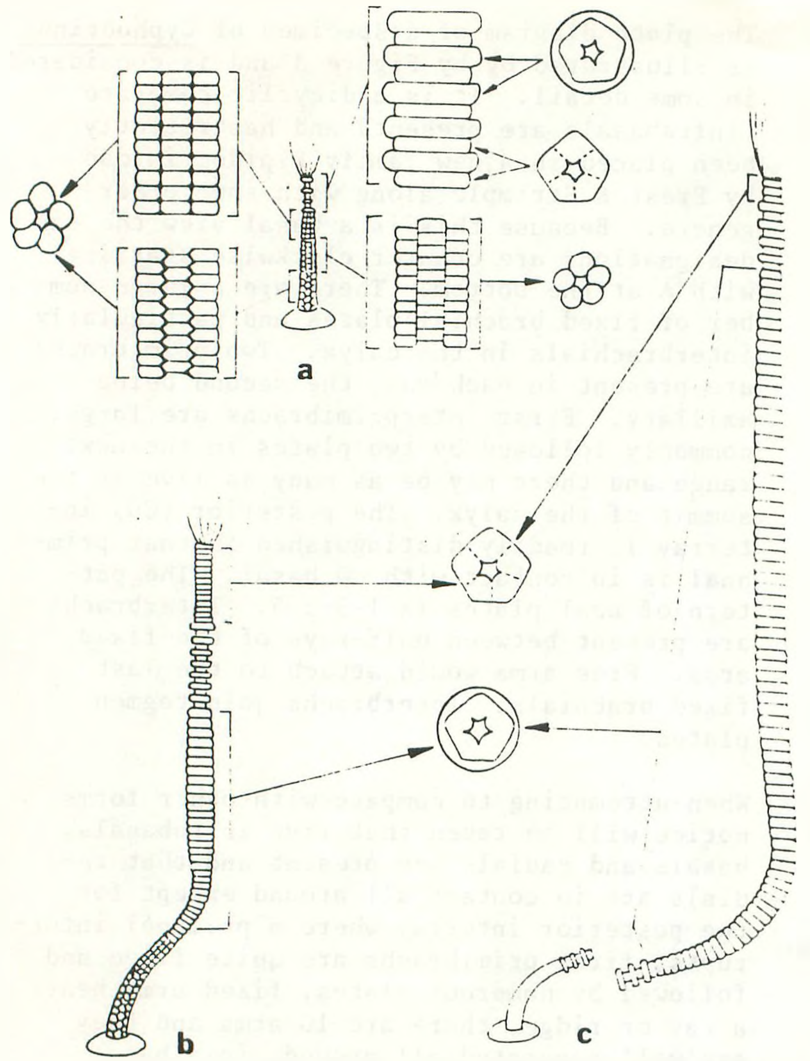


Figure 5. Ontogenetic change in the life habit of Cincinnaticrinus varibrachialus.

a. attached juvenile with polyplated (lichenocrinid) column and holdfast. b. attached adult with expanded, "adult" column proximal to the thin, juvenile (lichenocrinid) column. c. adult breaks free (whether because of increased activity or automization is unknown) at the attenuated juvenile column and thereafter lives unattached.

A more primitive type of stem is illustrated here (Figure 5) in which it is demonstrated how it started with polyplated elements which fuse to form single columnals. In Cincinnaticrinus varibrachialus youthful segments are in five parts which are radial in position, they fuse to form a pentagonal outline after which secondarily secreted stereom forms a rounded outline. The holdfast is in the form of a disk which is commonly attached to a hard surface and is composed of multiple tiny plates. For some time they were thought to be individual echinoderms and were given the name "Lichenocrinus."

As shown by Figure 5 there are five sections of different types and sizes of columnals in this one crinoid. It might be noted that many crinoids exhibit differences between proxisteles (those near the cup), mesistles (the main mid-section of the stem) andististeles (those near the distal termination). The terms are those proposed by Moore & Jeffords (1968) and bring to mind your need to know that proximal refers to the base of the cup (calyx or theca) and distal is away from the base. The fact that different types of columnals may and often do exist in the same animal has caused me to resist formal classifications based on isolated columnals or pleuricolunnals (several articulated segments). Nevertheless, several Russian investigators have done extensive studies as has Moore & Jeffords (1968).

There is an obvious need for study and identification of individual echinoderm ossicles (plates) because they are prolific in Paleozoic rocks. However, in my opinion, the proper approach is to link them with known articulated forms and, failing in that, to assign them to Collective Groups which is allowed under the existing rules of the International Zoological Commision. A case in point is the "twisted stem" of Platycrinites which many of you are probably aware of. Moore & Jeffords (1968) proposed a new genus for a "twisted stem" with Platyplateium texanum from the Pennsylvanian of Texas as the type species. The formation from which it was obtained is the same as that from which the calyx of Platycrinites remotus Strimple & Watkins was recovered. There is just not any justification for another genus and Broadhead & Strimple (1977) placed Platyplateium into synonomy with Platycrinites. In any event, if any of you have a compulsion to work with stem segments, there is a reference available.

Before leaving the subject some observations are in order. Very likely the ancestor of the crinoid did not have a stem but because of intense competition for available food, a stalk was created to lift them above the sea floor where they could filter food carried by the currents or "raining down" from above. As noted above the stem was polyplated but through time became single elements. The American Indian was aware of them and on occasion used individual segments as "wampum". There is no muscular articulation between the columnals or cirrals which caused many investigators to believe they were essentially rigid, however, recent studies of modern stalked crinoids have disclosed the ligamental structures contain elements which have properties which allow for movement. I was personally aware of the ability of cirri to move rapidly from reading an account of a dredging operation where stalked crinoids were brought up and the fastest moving elements were the lower cirri. It appears that when a crinoid is broken free from its attachment element the lower cirri are activated to clasp onto whatever is available. This is borne out by another narrative of finding stalked crinoids in which the lowermost segments of the stem always showed evidence of having previously broken free somewhere else and the cirri were firmly attached to the trans-Atlantic telephone cables. It was also noted that when the stem parts, it was usually just below a cirri bearing nodal. This indicates a deliverate arrangement in anticipation of breaking free (becoming eluтherozoic). You will notice that a free state is postualted for mature Cincinnaticrinus varibrachialus (which has no cirri) in Figure 5. In the latter case it is, of course, possible the lower (distal) part of the stem acted like a prehhensile tail and wrapped around an upright object, such as another fixed crinoid stem. At least some crinoids are known to take such action. When surface collecting I cannot resist picking up a segment of a stem with another wrapped around it because it tells the story so graphically.

Broadhead, T. W. and H. L. Strimple, 1977. Permian Platycrinitid Crinoids from Arctic North America: Canadian Journal. Earth Science v. 14, p. 1166-1175.

Moore, R. C. et al., 1968 (Crinoid Columns): University of Kansas Paleontological Contributions, Art. 8 to 10, supplement and one index, total 148 p., 16 text-figs., 27 pls.

A FACTUAL ACCOUNT OF THE IDENTIFICATION PROCESS -- Section 10

A frequent inquiry made by almost everyone is "How do you determine whether a form is new or not?" I recall the question was put to me by Dennis Burdick when he was a graduate student here at Iowa several years ago. My response was "When it looks different," which, of course, is an over-simplification of a very complex problem. At the time Grahme Philip was spending a sabbatical from Australia with us and had a desk in a corner of the old Repository in Calvin Hall. Burdick allowed he would find out from a "real" scientist, and I followed along behind to see whether I might pick up some pearls of wisdom myself. Dennis carefully put the question to Grahme, who quite seriously pondered it and responded "Well now a lot depends on how I feel when I get up in the morning." Naturally, neither of us are really casual about such matters but there are times when exhaustive research has failed to conclusively yield a clear cut conclusion and yet it is virtually certain the form does not conform to any previously known, so a decision may be made to propose a new name. A great deal depends on the morphological features the investigator considers to be significant or of most importance. Often an investigator with many years of experience will be influenced by quite different criteria than one lacking the advantage (or disadvantage) of familiarity with the problems involved. So it is that young investigators often have a built in disdain for work that has gone on before their time and may even express it in their work and attitudes. Certainly any investigator worth his/her salt will examine every detail with a critical eye but they need to take considerable care and consider the options before rejecting prior work. I can think of at least two studies in recent years which, in my opinion, have created confused situations which will require more effort to straighten out than it took to produce the problems.

As I outlined at the onset of this series, it is my intention to present current activity, reasoning behind the activities, etc, in the belief that more familiarity with the overall program will be beneficial to you. What I write now is something taking place, right now.

A graduate student in Frieburg, Germany, has been working on rock strata on the Island of

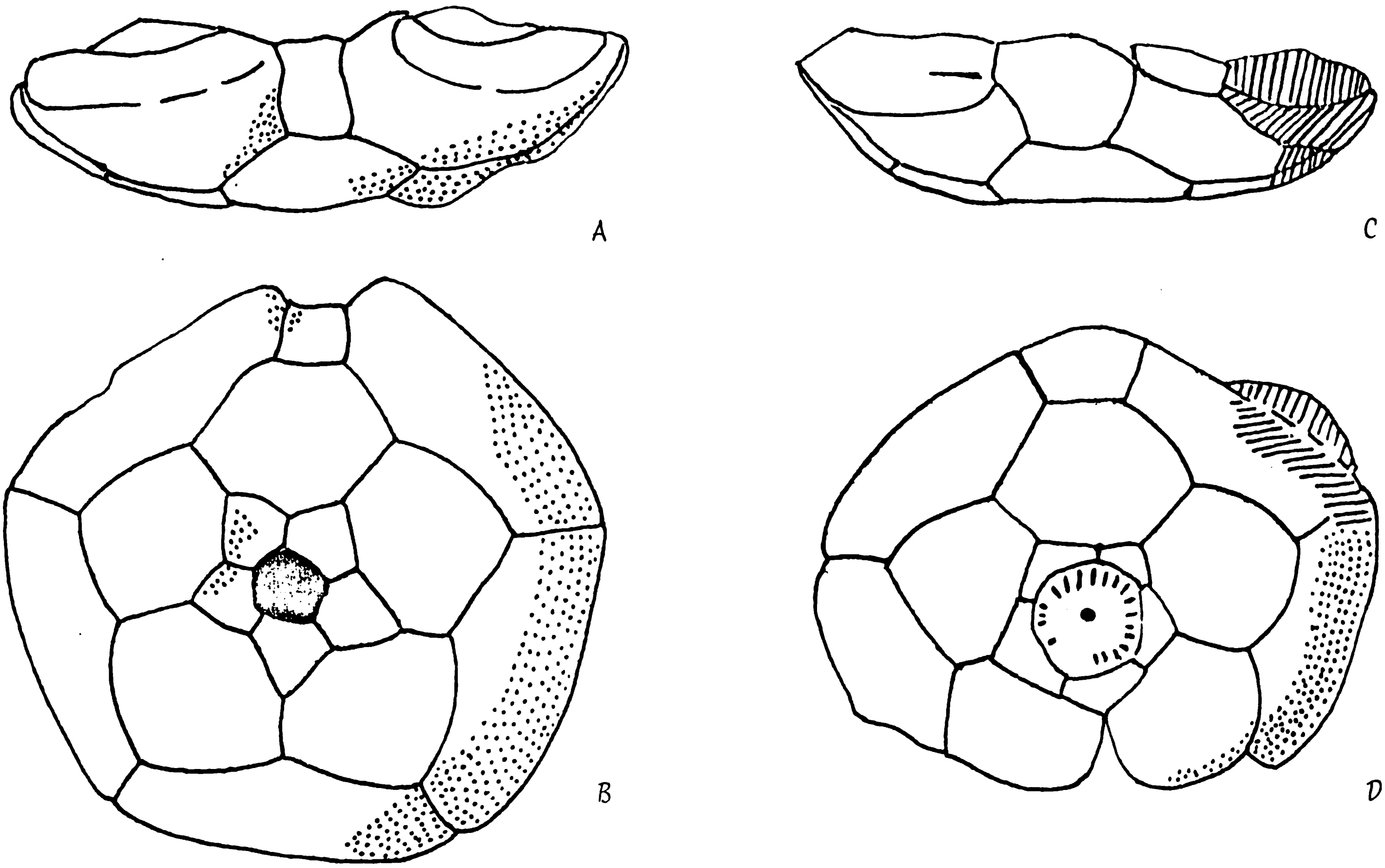


Figure 6. Sketches made with aid of a camera lucida: A, kB, Holotype cup of Moundocrinus coalensis from Coal County, Oklahoma, viewed from posterior side and base; C, D, cup of Aesiocrinus sp. from the Island of Crete, Greece, viewed from posterior side and base, enlarged X6.

Crete, Greece, for his Ph.D. project (dissertation). He found a stratum of rock exposed which contained Permian fossils, including a diagnostic ammonoid. Another parallel stratum close by contained a small crinoid fauna which he assumed to be late UpperCarboniferous (Pennsylvanian) or Permian. He attempted to identify the crinoids apparently be reference to the Treatise and then sent them to me for further evaluation. Five genera are apparently involved: Zenocrinus, Protencrinus Taidocrinus, Metacromyocrinus and Moundocrinus. Three of these are North American genera of about Moscovian age (Atokan or Middle Pennsylvanian), one is cosmopolitan (Protencrinus) of the same age, and only Taidocrinus is both cosmopolitan and ranges into the Permian.

So there is now a link between our genera (and strata) and Greece. I have previously made a slight link between northwest Spain and North America. In any event, there is quite a time gap between Permian and Moscovian.

The problem continues because the crinoids will be reported as a joint study. As an example of how I actually work toward identification, I have selected the single nearly complete dorsal cup which is thought to belong to Moundocrinus. When I first looked at it I noted a shallow cup, lack of a basal invagination, a single broad anal plate, wide but short articular facets on the radials; a mental checking process in which for one reason or another various genera are considered and rejected. After a day or so of thinking about it off and on, checking the most likely forms, etc., I decided that it was most like Moundocrinus and in some aspects like M. coalensis from the Atoka Formation of southern Oklahoma. I have prepared drawings of the holotype of M. coalensis as well as the specimen from Crete with the aid of a camera lucida (a mirror device whereby your right eye can see your pencil while you view the specimen with the binocular microscope). You are, therefore, able to compare the two species (Figure 6) and see the features which are alike and those which are not. Unfortunately, the stem area is lost in the holotype of M. coalensis and the proximal columnal in the Crete specimen is damaged although it appears to be round. M. osagensis the type species of the genus has a pentagonal shaped proximal columnal and is a somewhat taller cup with more erect sides. M. coalensis actually has a peculiar anal plate which, in a basal view of the cup, does not reach the perimeter; there is a shallow basal concavity (atypical of the genus) with slightly downflared infrabasals; basals are moderately large, and proximal tips of radials approach but do not reach the basal plane (hypothetical line under the lowermost points of the cup). As previously noted the anal plate of the Crete specimen is wide and it is confluent with the somewhat protruded CD interray. In that regard it is comparable to a form described as Oklahomacrinus canyonensis from the Cayon Fiord Formation (Middle Pennsylvanian) of southern Ellesmere Island, Arctic Canada. However, the latter species has smaller basals (except for the Cd basal), a broad basal invagination, and the proximal ends of radials form the basal plane of the cup. It is atypical of Oklahomacrinus but is also different to Moundocrinus, although it may be related to both genera. Actually, none of the three species considered here conform to all stated diagnostic characteristics of Moundocrinus or of Oklahomacrinus.

By this time I have screened all of the pertinent works by Wanner on the fabulous Permian crinoids of the Island of Timor, Indonesia, Lane & Webster's studies of Pennsylvanian-Permian crinoids of the far western United States, Trautchold, Yakavlev, Arendt studies of Pennsylvanian and Permian crinoids of Russia. But nothing seems really comparable. However, even as I write this two alternatives come to mind which are Polusocrinus and Aesiocrinus.

Polusocrinus is very close to Moundocrinus but differs in commonly having a taller cup and the single anal plate is faceted for the reception of two tube plates as opposed to one facet in the latter. The plates are commonly smooth (not tumid) in both genera. On the other hand, Aesiocrinus has a low cup, commonly has tumid cup plates, and a broad single anal plate in the cup which is faceted for reception of two tube plates. Both of these genera have proximal columnals with a pentagonal outline.

The specimen from Crete is closer to Aesiocrinus than to anything considered so far; however, the stem of the former appears to be round and the radial articular facets quite different from those of the latter. Aesiocrinus commonly has subhorizontal articular facets which are longer than those of any other genus discussed here. So the moment of truth is at hand, the specimen from Crete does not clearly belong to any presently known species or genus, although better preserved specimens might rectify the situation. In the meanwhile, it is not like other species, therefore, it will be described as a discrete species. Assignment will be made to Aesiocrinus but with reservation.

When I started writing this section I intended to assign the specimen from Crete to Moundocrinus although I had not started preparation of the manuscript. As I attempted to explain the rationale, my dissatisfaction increased, and I eventually adopted another option even though it is not fully satisfactory. The same thing might have happened when I prepared the discussion of the new species in the formal study. A final manuscript is often quite different from the first draft. There will be some who might think this account is contrived, but I do not need to "dream up" situations or experiences.

REGENERATION -- Section 11

Many years ago I read an account where gatherers of oysters in the Chesapeake Bay area cut up starfish which they caught in their oyster beds because the starfish were very efficient predators of clams. That is they cut them up until they finally realized that due to their amazing regenerating powers, the surgery was actually increasing the population drastically

It is fairly common knowledge that if one holds onto one arm of a modern brittle star, it will simply separate from the arm and leave it with you. Not so commonly known is that it will regenerate the arm, commonly in the same form as the original. There are instances where two arms will develop rather than one which is probably a malfunction. There are modern comatulid crinoids which are reported to add to the number of arms present by dropping off (autotomy) the upper portion of an arm and regenerating two arms to replace it.

In any event, the phenomenon of regeneration of crinoid arms or other elements is known to occur in Paleozoic crinoids. I have been aware of the matter for many years and usually call attention to regenerated parts when they appear in material under study. Apparently, the initial response is rapid in order to seal off vital elements such as nerves, hemal (blood) systems, etc. An excellent account of the action in modern crinoids is given by Hyman (1955, pp. 108-111). In essence two types of cells begin promptly with the regeneration tissue and transporting the food supplies so acquired to regenerating structures. The other type of cells which are filled with rods and granules assist in the regenerating processes while not themselves transforming into tissues.

Regeneration of an arm begins with the outpushing of the radial water canal accompanied by mesenchyme with the whole forming a slight bud-like projection. As the regeneration bud continues to grow, brachials arise in it by secretion from mesenchyme cells as in embryonic development.

I have observed a complete set of distal portions of the ten arms of a Protencrinus atoka Strimple which have been regenerated and have essentially grown to the same size as the original arms. Very likely regeneration takes place at an accelerated pace because the crinoid is mature and is capable of producing more stereom than when young, but it is still difficult for the new arms to attain a size comparable to the original.

My wife, Christina, has always been fascinated by the unusual specimens found in the fabulous La Salle Limestone (Missourian-Upper Pennsylvanian) crinoid "pools" she discovered, and she has established a "hospital" for such material. A specimen of particular interest was a flexible crinoid Enonychrocrinus simplex Strimple & Moore, which had lost the stem (all of it) and was attempting to regenerate in the large scar (cicatrix) at the base of the cup. Later on we found another that actually did regenerate about three small columnals in midportion of the large cicatrix. The important

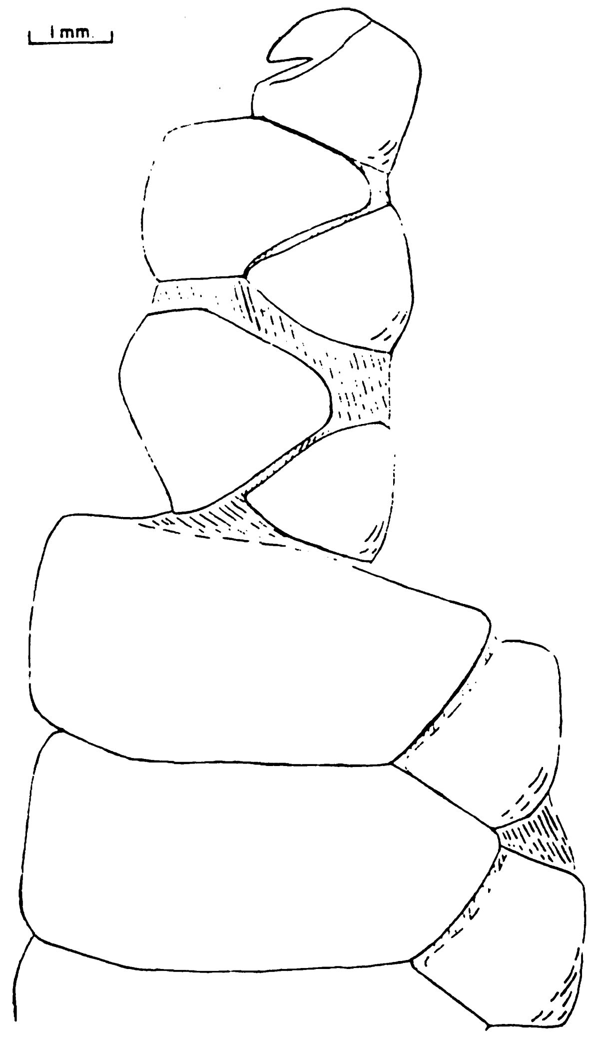


Figure 7. Drawing of a slightly disarticulated regenerated arm of Metacromyocrinus holdenvillensis Strimpla.

observation here is that the two specimens managed to survive while sitting on the ocean floor or were suspended above the ocean floor without the aid of a column. The late Edwin Kirk explained to me some 40 years ago that crinoids were essentially weightless in their natural elements (the ocean), but I have not been able to verify this and seem to generate opposition whenever I mention it. Be that as it may, the two specimens under discussion did not fall over into the soft muddy bottom and suffocate when they lost their entire stem, rather they lived and attempted to regenerate some sort of column. This is rather unusual in another sense because there is little, if any, evidence of Pennsylvanian, or any other crinoids, attempting to regenerate any part of the stem, although the distal protions of the stem are never found to terminate with a hold fast in the Pennsylvanian. Some flexible crinoids do have numerous distals cirri, which apparently acted as a "root system" to anchor them in soft mud. Holdfasts are also essentially non-existent in the Chesteran (upper Mississippian).

A report on the specimens of Enonychocrinus simples by Strimple & Frest has been published in the Journal of Paleontology.

I will mention another strange, unreported specimen in my wife's "hospital" which is a specimen of Stellarocrinus which lost most of its anal tube and regenerated two tubes. It is presumed the hind-gut also branched out and two points for ejected waste existed. There are other documented records of regeneration.

I once read an account of experiments with the lowly salamander in one of the many scientific magazines which I receive, and I presume it is factual. It seems the salamander is capable of regeneration of its extremities. The investigator severed the tail and when the initial "regeneration bud" appeared he carefully removed it and transplanted the bud into the side of the salamander where it continued to grow into a stubby tail, albeit entirely out of place. This account really impressed me because the implications of what could be done if we could just unlock the secret of regeneration is staggering to the mind. I suppose everyone knows that if one cuts a worm into two parts and then leaves it alone, there will soon be two worms. So much for the superiority of man over simple life forms. The lowly cockroach has been around for tens of millions of years and will probably walk over the remains of the last man or woman on earth. A rather depressing observation I must admit and not very original.

A CURRENT INVESTIGATION (FLEXIBILIA) -- Section 12 -- (New)

In Section 11 on Regeneration I gave an explanation of how one type of cell ingests injured or degenerating tissues and transports this food supply to regenerating structures. Apparently a similar process is utilized when a plate (or series of plates) is targeted for total or partial elimination. The process was mentioned in the section dealing with modification of anal plates in forms where the radianal is eliminated (resorbed) leaving anal X as the dominant and only anal plate in the cup.

In the species Paramphicrinus oklahomaensis (Strimple) young adults display the distal end of the large posterior basal and the main portions of the radial plates outside the columnal socket of the cup which is of course occuppied by the proximal columnals. New columnals are generated or formed in the confines of the socket, starting as extremely thin elements. In fully mature (gerontic) specimens the entire posterior basal and almost all of the radial plates are confined to the columnal socket which means that about half their normal thickness has been canabalized with the more rapidly growing adjacent columnals the probable recipient of the nourishment so obtained. It seems that some morphological changes of this nature are intended (programmed) to take place late in the development of some crinoids.

The disturbing thing about this information, which has not been previously recorded, is that

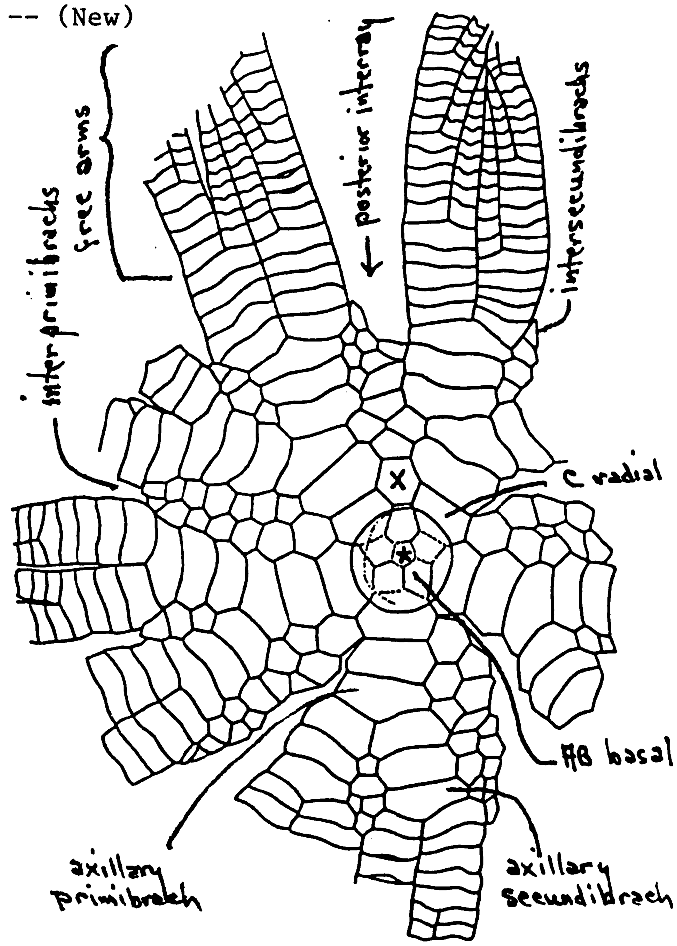


Figure 8. A drawing of the holotype of Paramphicrinus oklahomaensis (Strimple). The specimen is apparently a young adult of the species.

similar occurrences could take place without bearing any recognizable evidence. Another unrelated discovery, as yet unpublished, has been made concerning Paramphicrinus.

Throughout growth brachials are added at the distal ends of the arms. Branching of the arms in Paramphicrinus is rather complicated and it never ceases to amaze me how the creature knows when to produce an axillary brachial with two equal distal (upper) facets or an axillary with one large and one small distal facet. I read about the findings of genetic scientists but it only furthur amazes me. In any event the processes are not always perfect else there would be few or no abnormalities. What has not been known about the genus under discussion is that interbrachials are also added at the distal end of interprimibrachs series as well as intersecundilbrachs and intertertibrachs do not even appear until full maturity is approached. It is most unusual for calyx plates to be added (intercalated) once the calyx is formed but is known to occur on occasion and is even characteristic of the camerate family Acrocrinidae

When specimens are complete closed crowns it is impossible to see such things as pinnules (if present), anal sacs or tubes (unless they project above the arms), or the nature of the inner sides of plates. For this reason I have always attempted to obtain fragmentary and partial specimens. For example the articulating facets of the radial plates can not be studied if the primibrachs are preserved in place on the cup. I have a collector friend who probably still tells others that I am easy to satisfy because I am not looking for perfect specimens. This is somewhat short of the full story which he never quite understood, I need both but love a perfect specimen just like anyone else. It is true, however, that a considerable amount of information can be obtained from fragmentary material. As usual there is a definite point in all of this and it has to do with Paramphicrinus.

In the course of the present investigation which started with the small collection from the Island of Crete, Greece, the Flexibilia surfaced again because it is the most common form involved. As in the case of almost any crinoid form anymore I have studied them and puzzled over them many times before and often have uncompleted studies set back. The specimens from Crete are almost certainly congeneric with Zenocrinus Moore & Strimple a Morrowan genus which is unhappily described somewhat incorrectly (even in the Treatise). One thing leads on to another and I am hopelessly enmeshed even as I write this.

Zenocrinus is typically of Morrowan age (Lower Pennsylvanian) and in the same time period there is a species Paramphicrinus magnus Moore & Strimple. Today I decided to reexamine the type specimens of P. magnus which is a relatively large species. Preservation leaves a lot to be desired except for the interior of a cup which shows the nerve system (the center of the nervous system is thought to be located here) about the lumen (canal leading into the columnals) in the center of the cup and an internal structure on the left side of CD basal apparently for the reception of a rounded segmented rod-like device which will be discussed shortly. I recognized the potential of the specimen when we researched the species and arranged for it to be photographed at the University of Kansas Paleontological Institute. Unfortunately almost none of the fine detail came through. The late R. C. Moore elected to handle the flexibles for the study and some of his descriptions are based almost entirely on photographs rather than specimens (Moore & Strimple, 1973). I will give the reference at the end because there are 41 localities given in the locality register and some collectors might like to obtain them.

The internal structure on the left shoulder of the CD basal of P. magnus is of considerable importance. Such a structure was reported by Strimple in 1962 as being present on the left shoulder of anal X in specimens identified as Amphicrinus carbonarius Springer from the Oologah Formation (Upper Desmoinesian) of Oklahoma. Although it was not mentioned at the time of description a similar structure is found in Paramphicrinus poundi (Strimple) from the Stanton Formation (Missourian) of Kansas and is well shown in the Treatise (Fig. 547, 1h). Unreported specimens of P. oklahomaensis are known with as many as three or four free segments.

This is rather obviously a segmented rod-like structure. The base of the rod has changed positions from the CD basal in P. magnus to the anal X in stratigraphically younger species of the genus. In passing it might be noted P. poundi displays basal plates extending well beyond the columnals attachment area which serves to distinguish it from other species referred to the genus.

At this point your interest in investigative aspects is either running high, you have decided it is too complicated, or you are bored. I do not presume to speak for others in the profession who probably have an entirely different philosophy and working methods, but I have been brutally honest which in itself is a rare commodity, in my opinion.

Selected Reference

Moore, R. C. and H. L. Strimple, 1973. Lower Pennsylvanian (Morrowan) Crinoids from Arkansas, Oklahoma and Texas. University Kansas Paleo. Contr. Art. 60, 84 p., 23 pls. (Available from Director of Libraries, Univ. Kansas., Lawrence, Kansas $4.00).

FOSSILS AS INDICATORS OF TIME -- Section 13

Some life forms are better time indices than others, that is, they change with evolution in their observable skeletal morphology in a readily recognizable manner. Among microfossils foraminifera are very useful, and, for example, fusulines have been extensively utilized, particularly in the Late Paleozoic. Conodonts are utilized particularly in the Devonian and Silurian and in the past several years in the Pennsylvanian. Massive studies have not been made of microcrinoids, but they show promise.

Among macrofossils, ammonoids have proven to be the most reliable time indicators in the late Paleozoic starting in the Chesteran (Late Mississippian) upward. Like their modern descendants the "Chambered Nautilis" they were eleutherozoic (free swimmers) and so were cosmopolitan (distributed in oceans throughout the world). Starting with A. K. Miller, the University of Iowa has been the leading center of Paleozoic cephalopod study in North America. Russia has several outstanding ammonoid investigators and extensive collections. In fact the creatures have received considerable attemtion by specialists in many nations.

Echinoderms are often useful indicators but the occurrence of well preserved specimens is too sporadic to provide truly comprehensive universal coverage. Apparently dispersal usually takes place in the larval stage when the microscopic forms probably join the plankton. As I have noted elsewhere the length of time a particular species remains in this stage and the directions taken by the then prevailing currents probably control their distribution. Even the eleutherozoic (free) genus Agassizocrinus seemed to be limited to the United States until a specimen was reported by Webster & Gupta from India. A notable exception is the genus Scyphocrinites which is a very large stalked camerate crinoid that has a bulbous float at the distal termination of the stem. The float was originally thought to be a crinoid and was given the generic name "Comarocrinus." They are modified root systems which developed into a sophisticated, large rigid bulb-like form with partitions separating four hollow chambers probably occupied by a gas or by lighter than sea-water fluids. The genus was highly successful in Late Silurian and Early Devonian time with the almost indestructible bulbs forming continuous beds over long distances. In the Haragan Formation (Lower Devonian) of southern Oklahoma the bed has been traced for 50 miles. While a professor at the University of Malaysia, Tom Yancey (personal correspondence), told me of a local bed of crushed bulbs (apparently compacted by tectonic action). They are common in Europe (Bohemia) and Russia.

The bulbs are fascinating and we dig some out once in a while, sort of like grubbing for potatoes. Many of them have an attached epifauna (forms which attach to hard surfaces) mostly small crinoid root systems and occasionally the base of the crinoid Edriocrinus. I have suggested elsewhere that crinoid larvae conceivably attached to the bulbs while they are still floating and the larvae came to the end of its floating existence. However the floats could have been detached from the crinoid and sitting or lying on the floor of the ocean. There must have been a massive "kill" to have produced the acculations of bulbs observed in the Haragan. Small (young) bulbs are present, along with large (mature) bulbs.

We have taken samples of the soft marl associated with the bulbs in the Haragan and processed it to look for microcrinoids. They are quite rare but they are present. Because of secondary crystallization they do not photograph well with the electron scanning microscope. The sutures are also obscured so that I have been unable to make good camera lucida drawings. With time and patience, such a study could make a valuable thesis project or an expanded basis for a Ph.D. dissertation. There are also unreported microcrinoids in the Henryhouse and Brownsport Formations (Upper Silurian of Oklahoma and Tennessee). Cronise even reported a microcrinoid from the older Bromide Formation (Blackriverian-Ordovician) of Oklahoma in an abstract several years ago, and Jack Koenig (personal correspondence) told me he once personally examined the specimen. It is my personal belief that most microcrinoids are only distantly related to the Cyathocrinia. In older strata they are quite small (less than 0.5 mm) but they attain larger thecas by mid-Mississippian time which then makes it difficult to segregate the mature ones from other lineages.

As often happens I have wandered from my opening remarks, but I will note yet another application of some of the basic information. Considerable attention is being devoted in the past several years to many facets of geology, such as environmental conditions, ecology, plate tectonics, etc. During Pennsylvanian time the Ozark and Rocky Mountain uplifts were taking place, the epicontinental (partially submerged continent) seas were relatively shallow and flucuations (regressive and transgressive) were taking place. Regular patterns of change deposition resulted and are known as cyclothems. Professor Heckel (University of Iowa) is a specialist on the Pennsylvanian and on cyclothems. Conodonts represent another life form which has received intensive investigation here at Iowa through the years and Heckel has managed to link assemblages of conodonts with the transgressions and regressions. They have provided him with another valuable tool in his evaluation of the cyclothems and a new field of endeavor for students. Although not so sophisticated, Pabian and Strimple also have been able to identify certain crinoid faunas as being cold (deeper) water or warm (shallower) water. Expressed another way, this could be respectively "off-shore" or "near-shore." Much of this type of information has very practical applications in the search for proper or improper conditions for oil.

To leave this on a light note the conodont people have an informal organization called the Pander Society. It is not to be confused with "to pander," the first conodont to be reported was by a German named Pander. Although the society is informal in the sense that it has no officers and no dues it is very active and there is usually a major gathering every spring as a part of the North Central Geological Society of America meeting. They usually have a large section in any major meeting which includes paleontology.

The echinoderm people also have an informal Echinoderm Society but with their own newsletter once or twice a year and international gathering every two years, but it is dominated by modern echinoderm investigators. The fossil group run their own session at some major meetings and often have an evening together with refreshments at such meetings. It provides a good opportunity to visit old friends and competitors, exchange information, make deals, meet new "members" and students. It is usually quite lively.

Almost any collector learns early on that certain fossils indicate certain time periods. Then they learn that some forms exist which do not change for considerable periods of time.

BLASTOIDS (NOT IN DEPTH) -- Section 14

I would be the first to admit that I have never studied blastoids to any great extent; however, they are echinoderms and I have collected hundreds, even thousands of them mostly in Chesteran (Upper Mississippian) and Morrowan (Lower Pennsylvanian) strata. Hopefully, my earlier advice has been heeded and you have a reference book of some sort by now so that I do not have to go into an explanation of terms for the various plates and parts of the animal such as "brachioles" for the food gathering appendages. It is not uncommon to hear the appendages referred to as "whiskers." (I do it myself).

Blastoids are included in Part S of the Treatise On Invertebrate Paleontology and specifically in Section 1(2), published in 1967. There has been considerable published research on blastoids and allied forms subsequent to that time with probably the most noteworthy being Sprinkle (1973), and Breimer & Macurda (1972). In the former a new subphyllum Blastozoa was proposed to include a variety of apparently related forms. The latter is devoted to the fissiculate blastoids and is very comprehensive, except that it is poorly organized and very difficult to use.

The fact that I am by no means an expert on blastoids has not prevented me from doing a little investigating at various times. I found the first post-Morrowan blastoid in North America which was described as Paracodaster dotti Moore & Strimple (1942). It is a fissiculate blastoid and has received further attention; Fay (1961) referred it to a new genus Agmoblastus; Briemer & Macurda (1972) then referred it to the genus Angioblastus but this action was rejected by Strimple & Mapes (1977) who also described a new species from Texas as Agmoblastus caddense.

The holotype of Agmoblastus dotti was a smashed specimen embedded in a slab of limestone. It represents a fair story in itself. I knew a fossil collector by the name of Paul McGuire who was a Section Foreman on a spur line at a cattle loading station called Strohm in Osage County. He had a friend, E. L. Banion, who was a traveling inspector on the railroad and knew about a crinoid bearing exposure at a railroad trestle across Double Creek on the north edge of Romana, Washington County, Oklahoma. The railroad had cut into the Hogshooter Formation (Upper Pennsylvanian) and probably the only real bioherm (a type of reef structure) in Oklahoma, albeit a small one. An unusual coral assemblage also occurs here and Strimple & Cocke (1973), described the corals and crinoids of the Hogshooter Formation. I first met Cocke when he was a Masters candidate at the University of Oklahoma working on the Dewey Limestone Formation of Washington County, Oklahoma. Allagecrinus strimplei Kirk, now Kallimorphocrinus strimplei (Kirk), which is the crinoid that started me into a career of crinoid research, is from Dewey limestone. All of this account shows how an ordinary discovery may be made by an amateur and can end up as a series of studies or in some cases even a major study. I can think of a half dozen studies due at least indirectly to the collectors, McGuire and Banion.

In late June of 1962, I was on my way to Iowa City to start work as a Curator and Research Associate in the Department of Geology at the University of Iowa. I had a U-Haul Trailer full of books and clothes and the knowledge of Pentremites as well as an occasional crinoid having been found in the County Quarry north of Oskaloosa, Iowa (from Allen Graffham). So I wheeled into the quarry (operating at the time) and looked it over briefly (no specimens collected).

I could not even estimate how many times I have collected there through the years. Most of my collecting expertise has been surface collecting and at the Oskaloosa Quarry most collecting is in spoil heaps of the soft shale which rests on the top of the quarry rock of the Pella beds (now formally named the Pella Formation) which is probably lower Chesteran in age. Almost all echinoderms are small although there are corals and brachiopods which are of comparable size to those from other areas. Perhaps the water was too shallow to allow crinoids and blastoids to develop in a normal manner.

We have always identified the Pentremites from the Pella as P. conoideus but I have recently been advised by Alan Horowitz, Indiana University, that it will be considered as another species in a forthcoming revision of Pentremites by Horowitz, Macurda and Waters. I loaned 2,000 specimens from Iowa collections to the study. Horowitz visited us in Iowa City recently and was more than a little impressed by the thousands of specimens in my wife's (Christina) collection and we agreed a study of such a collection (all from one horizon in one locality) would make a highly valuable data set. As a matter of fact, the idea was not new, Christina had already screned the collection for abnormal specimens, also those with an oral pyramid or brachioles. We concluded that about 1 in 100 was abnormal. But a formal study requires exact observations. Fortunately, a student approached Horowitz looking for a project to earn three hours credit not long after he was here, so it may well be that we will have a "classic" study in the not too distant future. Who knows, I might even finish the study of crinoids from the Pella some day.

A Ph.D. candidate (Steven Katz) under Sprinkle at the University of Texas, Austin, worked on Pentremites (a spiraculate blastoid) from the Morrowan stage as his dissertation. He contacted me and I sent him 500 beautifully preserved specimens from the Chisum Quarry near Gore, Oklahoma. It turned out he was interested in the hydrospires which are internal respiration devices and he sectioned (cut) every one of them. When he contacted me the second time for more I declined. What he was really looking for was a verification of a phenomenon he had discovered in one specimen which was the presence of small spherical objects in the hydrospire and canals. He never found another example, but, even so, he and Sprinkle postulated they were eggs and published the same in Science (American Association Adv. Sci.).

I don't remember how I became aware that Allen Graffham (Geological Enterprises) had specimens of Pentremites with stems and holdfasts, perhaps from his Bulletins, but in any event, I purchased them for $200 as I recall. They were from a locality that I had collected heavily for several years which is the Fraileys Formation (Chesteran) east of Anna, Illinois, and I had a few specimens with the stem attached but none complete. I then researched all of the literature and was unable to find a single record of a complete blastoid of any age with stem and holdfast, although there were a couple of "reconstructions." The matter is now recorded, Strimple (1977).

It is not easy to fault oneself, but I will admit that my primary concern when working the Fraileys east of Anna was to obtain "free" specimens so that I could examine them from all sides. Because of this I subjected slabs which I recovered to water and brush. Thus, specimens which were impressed on the slabs with a shale layer on top were indeed recovered but not with much or any of the stem attached. This was true of crinoids and blastoids alike. Conversely, Graffham exposed his material with the aid of an airbrasive and thus retained the stem of the blastoids on the surface of the slab. From a practical viewpoint I could not do otherwise because there simply was not enough storage room for all of the material I recovered in that operation or enough time to utilize the airbrasive machine to such a degree. I was working the Fraileys, the Renault at Waterloo, Illinois, the Menard at Chester, Illinois, the Paint Creek at Vogel School (Prairie du Long Creek) and Carr Creek near Columbia, Illinois and the Beech Creek Formation north of Hecker, Illinois all about the same time with several diversions. When I look back it amazes me, but it did happen and more than a little bit has been recorded in the literature.

It has been an enigma that both spiraculate and fissiculate blastoids are present in the Permian of the Island of Timor, Indonesia and to a lesser degree in the Ural Mountains of Russia, whereas spiraculate blastoids flourished in the Morrowan (Lower Pennsylvanian) then disappeared in the United States. Fissiculates seem to be absent in the Chesteran and Morrowan but then appear again in Missourian (Upper Pennsylvanian) rocks albeit rarely. If I understand correctly, a few spiraculates have been recovered by Royal Mapes (Ohio University) who has been processing thousands of pounds of shale of Pennsylvanian age in search of cephalopods, and seed pods (his wife, Gene Mapes, is a paleobotanist). In any event, it is obvious that spiraculates and fissiculates survived some places into the Upper Permian, but thereafter they apparently ceased to exist.

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MISCELLANEOUS NOTES -- Section 15

One files away a considerable amount of information in one's memory bank and then recalls it as one needs it. When younger, I had the ability to recall the source of bits of stored information, but with age the exact references have slipped my memory. So it is that I new find myself with much information which I would be hard pressed to trace to the source.

For example, I once read that some modern stalked crinoids are composed of some 1,200,000 (I think it was more) individual assicles (plates). Of course, this would include each individual cirral (plural is cirri), columnal, brachial, pinnulars, tegmenal plates, etc. One can readily believe it when examining a limestone like the Burlington Formation composed almost entirely of skeletal plates of crinoids.

Geologic time to a geologist or paleontologist is quire different to that related to every day living. I remember a talk I gave several years ago in which I explained a certain species was younger than another which explained the more advanced morphologic features. In the question period after the talk someone asked me how much time was involved and I had to admit that I had not thought about it. Both species were of Devonian age but the "younger" came from a higher stratigraphic unit. When I checked into the matter I found it was 3,000,000 years younger, give or take a few years. When a geologist speaks of an instant of time it is in the range of 100,000 years, in a geological context. So it is when you read about the rather new concept of "rapid" evolution having taken place in various fossils groups as opposed to "gradualistic" evolution the connotation of sudden does not mean that today you have one lineage and tomorrow another.

In the case of crinoids and any heterosexual life form, there has to be a compatible gene pattern in any given species as between eggs and sperm else the resultant form does not perpetuate itself. It has always bothered me how two closely related crinoids could coexist without crossing. And then I read how it happened in some modern crinoids. On a given day the females of one species will release swarms of eggs say from 7 AM to 11 AM and the males (with a chemical stimuli?) release sperm. Perhaps at 4 PM a coexisting crinoid species releases eggs until 7 PM. There are numerous studies which prove that species are not necessarily unable to cross with other species but for one reason or another do not do so. So much for a doctrine from my youth, and still alive, that one species is unable to breed with another without producing a sterile offspring.

The dispersal of the larval crinoid is fascinating and for this, one must depend entirely on the modern crinoid for information. Fossilized microcrinoids (5 mm or less) are not larvae because they have a fully articulated skeleton. Because they are minute they are often referred to as larviform, and I like the term myself but not in a formal sense. A larvae has no skeleton and is in fact essentially a minute, more or less spherical blob with a gut. They are usually free although I have seen illustrations where some apparently stay with their mama (?) and attach to an arm presumably until reasonably mature. The surprise is that they escaped being eaten by her. But most are suspended in the current during their "doliolaria" stage when they have hair like cilia which provide a certain amount of movement on their own. It is presumed their range of travel depends on the rate of current and the length of time they are in this stage. A metamorphosis eventually takes place and they sink to the bottom ready for their attachment stage. This is a very critical time because they attached to any surface available. If it is only a grain of sand they are not long for this world. A study by Alissa Clark notes that embryonic crinoids in the North Sea swarm into the coastal areas of Holland, Denmark, etc., but they are soon dead.

To demonstrate how this works in the fossil record, there is an interesting exposure near Mound City, Kansas, which is a highway road cut. A calciludite (limestone) in the Ladora Shale, Missourian Stage, Pennsylvanian, is present. Dr. P. H. Heckel (before he joined our staff at Iowa) was leading a field trip and made a stop at the exposure. Prof. Gilbert Klapper from the University of Iowa noticed a small accumulation of linoproductid brachiopods in the limestone. Some brachiopods are very opportunistic and will invade an environment which is too hositile for most invertebrate sea life. A clump of the brachiopods was extracted and Heckel retained it at the Kansas Geological Survey in Lawrence, Kansas. When he scrubbed the clump of brachiopods he found small crinoid stems on the upper surface and closer examination disclosed several small crinoid crowns. For many years I enjoyed very close ties with the Survey and the University of Kansas (almost all my friends have left there one or another), and he showed me the specimen and allowed me to take it to Iowa. I managed to completely free one of the small crowns from the matrix and described it as Planacrocrinus klapperi Strimple & Heckel, in 1978, after Heckel became professor at the University of Iowa.

A strange thing about the species is that although it is a camerate crinoid, the arms are indistinguishable from those of the inadunate crinoid Erisocrinus. But back to the primary point. It is obvious the crinoids came in on the current from somewhere else as floating larvae and those which happened to settle on the hard surface of the large brachiopods survived and grew up quite nicely.

I recall another instance in which large linoproductid brachiopods probably accounted for the presence of crinoids. The brachiopods were in a thin lentil of sandstone in the Atoka Formation, Atokan Stage, Middle Pennsylvanian in Coal County, Oklahoma and crinoids were mixed in with them. One just does not expect to find crinoids in sandstone although it happens on rare occasions. A small "colony" of nothing except Parcymbiocrinus ormondi Burdick & Strimple was found in an essentially barren ancient sandstone bar in the Imo Formation (uppermost Mississippian) south east of Leslie, Arkansas. Those on the surface and for some distance inward were leached out leaving molds but well below the surface they were intact and I was able to expose a few with the aid of an air-brasive machine. The quartz of the sand grains was obviously harder than the dolomite powder and it was a long tedious process in which most individual quartz grains were removed with a needle.

The random distribution of larvae provides an explanation for the fact that some crinoids which have apparently been modified for life in say a reef environment are also found in non-reef environments. There are many factors involved in whether crinoids can proliferate or even survive in any given area. The water must be sufficiently oxygenated, there is an acceptable range of salinity involved, some species are temperature sensitive (apparently most do best in a warm or temperate situation), there must be an adequate food supply, the currents must not be too strong, too much suspended silt in the water will suffocate them.

As in any life form competition between various crinoids in any given area takes place. One of the most common crinoids in the Missowian Stage (Upper Pennsylvanian) is a small crinoid genus Apographiocrinus. There is also a genus Contocrinus which is so much like it that most collectors or even investigators have a little trouble separating them. Commonly Contocrinus is somewhat larger in maturity and usually when it is found it is associated with Apographiocrinus. Contocrinus is not uncommon in the large poplations found in the La Salle Limestone of Livingston County, Illinois, but Apographiocrinus is far more prolific. It is only at one exposure in an argillaceous shale of the Wann Formation (Missourian) near Ochelata, Washington County, Oklahoma, that the genus has been found to numerically hold its own with Apographiocrinus.

Apographiocrinus (as well as Contocrinus) has a low bowl-shaped cup, has reduced the anal plates to one, maintained ten simple (uniserial) arms which branch with the first primibrach, and is small (average height of crown about 22 mm or less than an inch). Apographiocrinus is by far the most prevalent and widely distributed crinoid in the Missourian Stage of the mid-continent of the U.S. But it is not known east of Illinois exdept for an occurrence in the Woodville Sandstone in Michigan (see Strimple & Duluk, 1971, Earth Science, v. 24 (5), p. 242-244). Strangely enough, it is also present in Upper Permian rocks of the Island of Timor, Indonesia. I expect it will eventually show up in the eastern United States and probably in Russia. It was surely an adaptive, successful crinoid genus for an unusually long period of time (tens of millions of years).

PARACRINOIDS -- Section 16

With the demise of Cystoidea as a viable taxon several higher taxa have been advocated. Some conservative specialists have resisted many of the new higher taxa and indeed it does appear that some questionable divisions have been proposed. My personal feeling about these matters is that we need to concentrate more on understanding lower taxa (species, genera, families) before we tinker much with superfamilies, suborders, orders, etc. This might

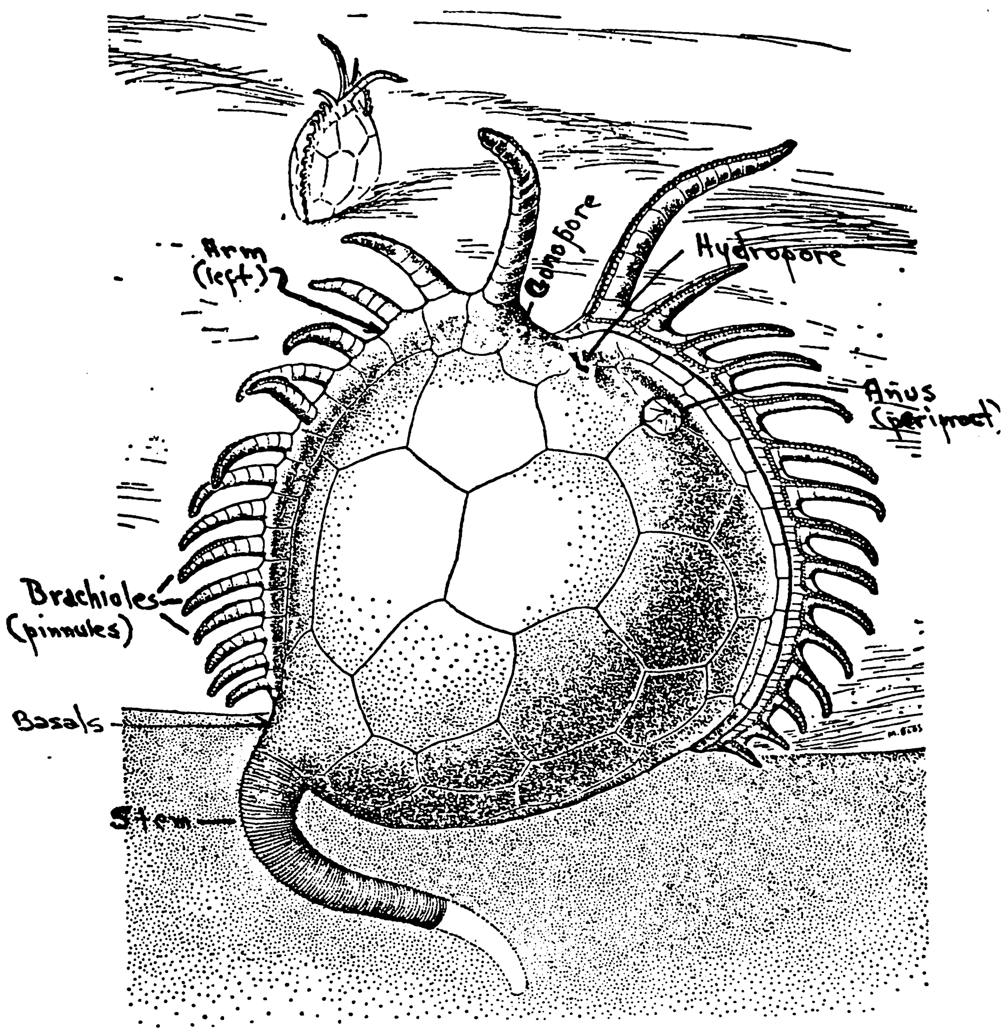

Figure 8. Globulocystites cristatus (Bassler). Modification of a reconstructiion of the posterior of a specimen which reflects the opinion of J. W. Durham as to the living position of this species. Some morphological features are pointed out.

indicate that I am "conservative" but "moderate" seems more appropriate to me. Paracrinoids are considered here. Some of you will recognize the name Oklahomacystis from the Ordovician (Bromide Formation) of Oklahoma which is commonly called a "cystoid" but is actually a paracrinoid.

There is no doubt that paracrinoids are distinctive. Jaekel (1900) placed most of the involved genera in his order Eustela of the class Carpoidea, however they are obviously not related to "carpoids". Regnéll (1945) was the first to propose a separate class which he named Paracrinoidea and this was accepted by Kesling (1967) in the Treatise. A further division was made (but no longer accepted) between those forms in which the arms are recumbent and attached to the theca (order Varicata Jaekel, 1900) and those in which the arms are free above their proximal attachment to the theca (order Brachiata Jaekel, 1900). Parsley and Mintz (1975), in a comprehensive review, proposed a new subphyllum Paracrinozoa, however they only recognized nine genera as belonging to the group and there are other problems which we believe are yet to be resolved. In the meanwhile we have withheld acceptance of Paracrinozoa and have pursued several avenues of inquiry.

Platycystites faberi, type species of the genus, was proposed on the basis of a poorly preserved theca of questionable origin, however it is rather certain that it is of Blackriverian (lower Middle Ordovician) age from Scott County, Virginia. Several well preserved specimens were recovered by Coney in the process of our "Rye Cove Project" and provided a firm basis for proper evaluation of species and therefore of the genus. The species is bilaterally symmetrical with two equidimensional endothecal arms (arms attached to the theca) which extend the full length of the theca. Most paracrinoids are asymmetric with an offset stem attachment area. The primary plate pattern is obviously more easily established in P. faberi because of its symmetry. Frest, Strimple & McGinnis (1976) documented some of this information. This was followed by Frest, Strimple & Coney (1979) in a comprehensive study of paracrinoids in which asymmetric species (such as the prolific P. cristatus were removed from Platycystites and assigned to Globulocystites Frest, Strimple & Coney.

It appears that Platycrinites faberi was elevated above the substrate (sea floor) by an erect column (or stem). The life position of the lineage became recumbent on the sea floor (Globulocystites), as evidenced by the offset column attachment facet and the shortening of the right arm (figure 8). The side with the short arm also widens to form a more expansive surface for contact with the substrate.

The youngest known paracrinoid is from the Hopkinton Dolomite (Llandoverian Early Silurian) of Iowa and was described as Ovulocystites hopkintonensis Frest, Strimple and Witzke (1980). It is closely related to Oklahomacystis and both of them belong to the family Amygdalocystitidae.

In the spring of 1981 Frest & Strimple gave a paper at the North Central Geol. Soc. Amer. meeting in Ames, Iowa, in which it was suggested that all members of the family Springerocystidae were actually paracrinoids and that the included genus Foerstecystis is a junior synonym of Cryptocrinites which genus has previously been considered to be an eocrinoid. All of this is the result of reexamination of thecal morphology and discovering that basic plate configurations are comparable except that the genus Bockia is not yet decipherable.

There will be a new study appearing in the Journal of Paleontology in a few months dealing with the order Comarocystitida Parsley & Mintz (1975) with emphasis on genera from the Kimmswick Formation. This was the first outright hostile opposition we have encountered. As a rule differences of opinion are worked out in print where the peer readership is able to either accept or reject based on the information as it is presented. This was the first time in my career where a peer reviewer attempted to block publication. Fortunately the editor obtained a third opinion due to the "overkill: nature of the one negative review.

Two small studies are also underway dealing with an exotic species of the genus Amygdalocystites from the Galena Formation (Middle Ordovician) of Iowa and what appears to be a new genus and species of Paracrinoidea from the Osgood Formation (Silurian) at Napoleon, Indiana. Our only specimen of the Osgood is a juvenile found by Bruce Gibson. There are two other larger specimens which we have attempted to trade for or purchase but to no avail. This is an excellent example of the frustration often encountered by investigators which I have mentioned elsewhere in this series. The Osgood specimen will be the youngest representative of paracrinoids, if indeed it is a paracrinoid, yet encountered.

If you get the impression paracrinoids are unusual, not too well understood creatures, you are perfectly correct. Most of the genera are relatively rare and restricted to the

CURRENT CLASSIFICATION OF PARACRINOIDS

Phylum ECHINODERMATA
- Class PARACRINOIDEA
  - Order COMAROCYSTITIDA
    - Family COMAROCYSTITIDAE
      - Genera Comarocystites, Sinclairocystis, Implicaticystis
    - Family AMYGDALOCYSTITIDAE
      - Genera Amygdalocystites, Achradocystites, Oklahomacystis, Ovulocystites
  - Order PLATYCYSTITIDA
    - Family PLATYCYSTITIDAE
      - Subfamily PLATYCYSTITITINAE
        - Genera Platycystites, Globulocystites
      - Subfamily CANADOCYSTINAE
        - Genus Canadocystis
    - *Family CRYPTOCRINITIDAE
      - Genera Cryptocrinites, Springerocystis, Columbocystis, Bockia
    - Family MALOCYSTITIDAE
      - Genera Malocystites, Wellerocystis
    - Family BISTOMIACYSTIDAE
      - Genera Bistomiacystis

*May eventually be divided between other families.

Ordovician but do extend into the Silurian. No doubt there will be more found in the future. I suspect there are already specimens tucked away in collections which are just oddities to the collectors.

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SOLUTAN CARPOIDS -- Section 17

My first experience with carpoids came about with description of a single specimen of a new genus and species from the Bromide Formation (Ordovician) of southern Oklahoma as Myeinocystites natus Strimple, 1953. At that time Belemnocystites wetherbyi Miller & Gurley, 1894, for the Curdsville Formation (Ordovician) of Mercer County, Kentucky, was the only closely related taxon. Parsley in Caster, 1968, p. S623, proposed a new family Belemnocystitidae with only Belemnocystites (and its type species B. wetherbyi) included. However, at the end he showed "(? = Myeinocystites Strimple, 1953)." Presumably, this meant that he was not certain about the genus Myeinocystites or did not care to comment at that time. It was a strange notation but in any event Parsley (1972) did accept Myeinocy-

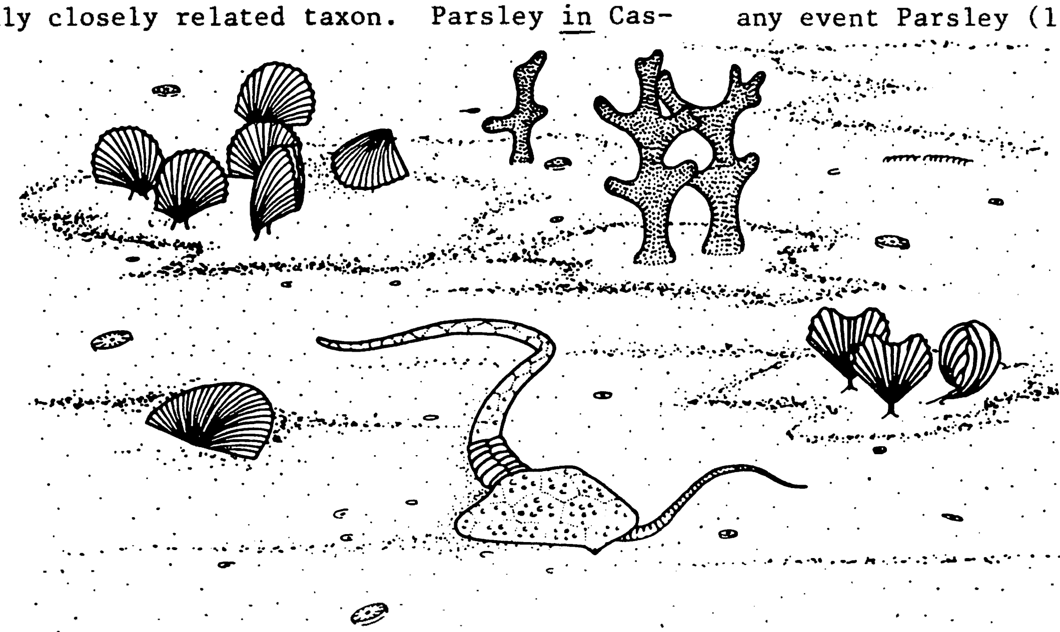

Figure 9. Reconstruction of Middle Ordovician sea floor showing inferred life mode of Scalenocystites strimplei Kolata, 1973, (from Kolata et al, 1977)

stites as a valid genus and, in fact, considered another specimen from the Benholt Formation of eastern Tennessee to be conspecific with M. natus. Kolata, Strimple & Levorson (1977, p. 544) confirm that the plating arrangement on the oral face of the Benbolt specimen is quite similar to that of a topotype specimen (an additional specimen from the type locality of the species) of M. natus.

Kolata (1975, p. 15) described a form from the Galena Group (Ordovician) near Rockford, Illinois, as Myeinocystites natus Strimple, however, in the Kolata, Strimple & Levorson (1977) study, the two Illinois specimens were designated as the holotype and a paratype of a new species described as M. crossmani. Three specimens from the Galena Group near Burr Oak, Iowa, are paratypes. The specific appellation is for Glenn C. Crossman, an advanced collector and member of MAPS, who collected some of the type material.

Kolata, Strimple & Levorson (1977) in revision of the family Iowacystidae Gill & Caster (1960) synonomized Belemnocystitidae. The Iowacystidae now includes Iowacystis, Belemnocystites, Myeinocystites, and Scalenocystites. Due to poor preservation Belmnocystites is the least well known of the family. Kolata reflected light from the optically oriented crystals within the plates of the holotype and concluded the pattern of the oral face plates in B. wetherbyi is essentially the same as found in Myeinocystites natus. He prepared two drawings--one of the oral side (which is published, 1977, text--(Figure 10) and the aboral side. The sutures between the marginal plates on the oral side did not match those on the aboral side and in addition the published drawing shows a marginal plate between M4 and M5 which is not present on the aboral side. Fractures, which are numerous, also prevented me from being able to accept Kolata's interpretative drawing or conclusion concerning this matter.

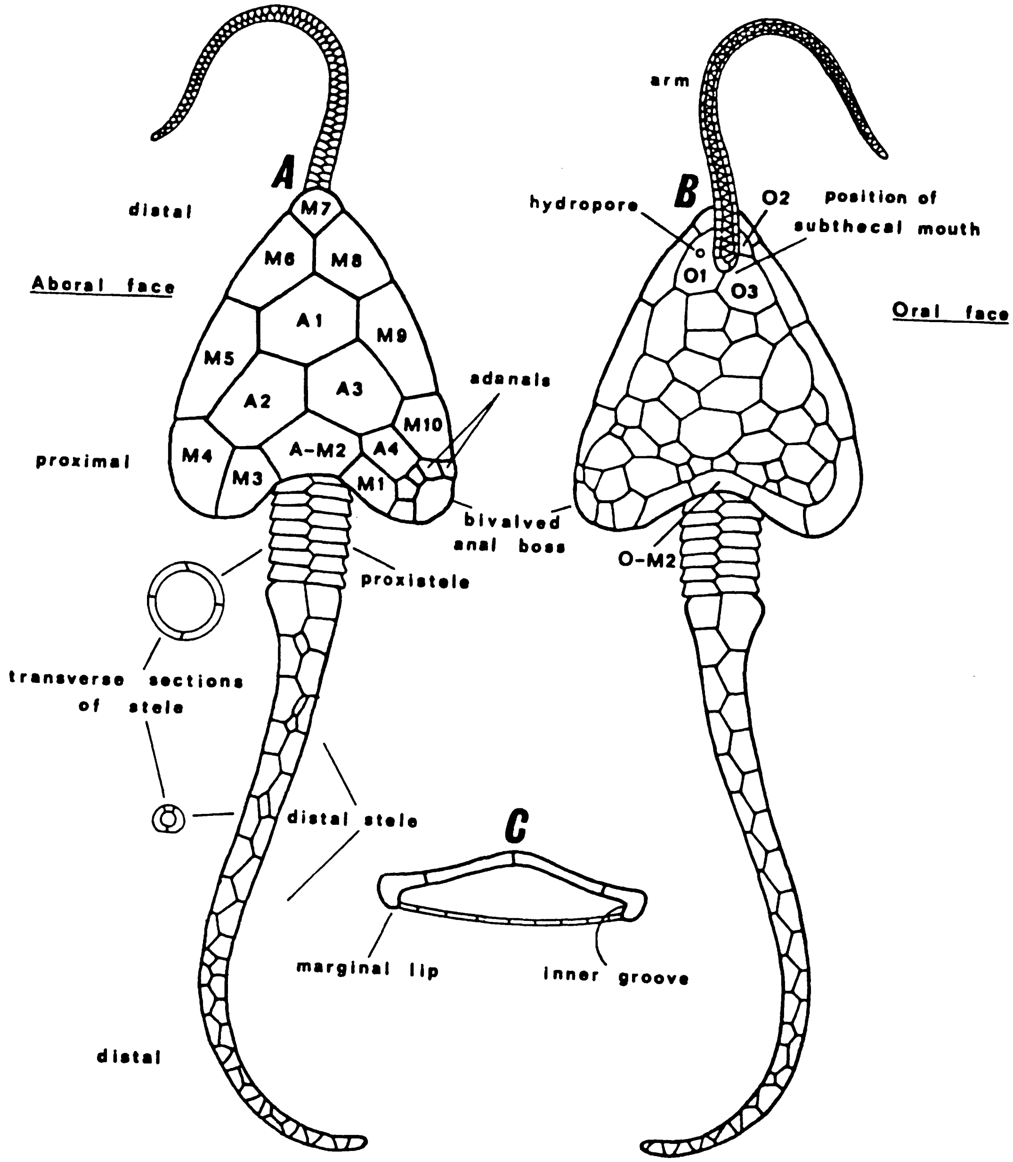

Figure 10. Iowacystid morphology and terminology based on Iowacystis sagittaria Thomas and Ladd, 1926. A, aboral face, B. oral face, showing revised thecal plate nomenclature. C, transverse section of the theca showing the relatively thick aboral plates (upper surface) and nature of contact with thinner, more numerous oral plates (lower surface). Approx X1.5 (from Kolata et al, 1977).

Iowacystis Thomas & Ladd (1926) is only represented by its type species I. sagittaria Thomas & Ladd (1926) and is endemic (restricted) to the Maquoketa Group (Upper Ordovician) in northern Iowa. Dr. A. O. Thomas was a professor at the University of Iowa and was interested in the echinoderms of Iowa making considerable contribution to the knowledge of Ordovician and Devonian forms. Both H. S. Ladd, L. R. Laudon and the late M. A. Stainbrook were graduate students under his supervision. Ladd directed most of his attention to the Ordovician, Laudon to the Mississippian and Stainbrook the Devonian of Iowa.

The story of Scalenocystites Kolata is sort of complicated. My wife, Christina, knew some fossil collectors in Ste. Genevieve, Missouri, Loyal and Dorothy Hammack, and one time we were about to pass through their town, and she suggested we look them up, which we did. They asked me if I would give a talk to their rock club in St. Louis, which Ieventually I did. Quite a few interesting things came out of the situation which were certainly advantageous to the increase in knowledge about echinoderms. But the case at hand concerns the carpoid Scalenocystites. Bruce Stinchcomb professor at Florissant Junior College, together with his protogé, Guy Darrough, had collected from a small quarry nearby Cannon Falls, Minnesota, out of the Dunleith Formation, Galena Group (Ordovician) and found the strange carpoid. I managed to trade for and purchase a couple of specimens and also found one or two poor specimens myself when returning from a Geological Society of America annual meeting which was held in Minneapolis, Minnesota. Kolata was still a graduate student at the University of Illinois at the time but was quite excited about the specimens which I turned over to him and he described them as S. strimplei Kolata (1973). As it has turned out, the species and the genus is known only from the one small Wagner Quarry which has subsequently been totally worked out. A Master's candidate at the University of Minnesota, Lance Grande, recovered quite a bit of material in the last days of the quarry operation and I purchased a couple of specimens from him before he went to New York to become a Ph.D. candidate at Columbia University. Lance had a table at either Expo I or Expo II.

Many collectors think that these forms are disfigured because they are more or less flattened as opposed to being rounded like most echinoderms. In this regard, they might be compared to the modern "sand-dollar" (echinoid). Many pleurocystids (rhombiferan cystoids) have a somewhat comparable theca but there are several significant differences. It is generally accepted that they were mobile (eleutherozoic) and used the stele for locomotion. At one time there was some controversy over whether the oral side was directed upward or downward in life but the well preserved material which I have been able to "round up" one way or another in the past several years has resolved the matter. The illustration given here (Figure 9) shows the proper living posture, that is, with the oral surface down. In that the ambulacral (food gathering) groove of the single arm is also directed downward it follows that the carpoid was almost certainly a detritus feeder.

It is my considered opinion there are many more of these strange little beasties to be discovered when collectors become aware of their existence and learn to recognize them in the field.

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SUPPLEMENTAL NOTE -- Repeat

In an article published in the November, 1981, issue of MAPS DIGEST (vol. 4 no 10) MOSTLY ABOUT INVERTEBRATE FOSSILS -- Results of Cooperation-- Section 3, I touched on microcrinoids from Lake Valley, New Mexico and several members have exhibited an interest. Considering they range from smaller than the dot over an "i" to somewhat larger, one must have good optical assistance to find or study them. Even so microfossils can be great fun and require minimal storage space. Nikon has a good student zoom binocular microscope and it is the sort of thing one need only purchase once in a lifetime. There are several relatively inexpensive (not cheap) binocular microscopes for this type of study. Spencer and Bausche and Lomb zoom binocular scopes are good but somewhat more expensive than Nikon. Inclined eye pieces will save one a lot of strain on neck and shoulders. With eye pieces X10 the zoom power is commonly from X7 to X30. A screw on lens X2 will double that or one at X0.5 will halve it. They are seldom, if ever, needed. They have a dual purpose and are indispensible for careful cleaning of macro-fossils or even careful examination of them at low power.

I have three friends in north central Iowa who are serious collectors and they pooled their money to purchase a zoom binocular (the "zoom" is a dial which can be turned to increase or decrease the magnification). They share the instrument, passing it around from time to time with the main use for small fossils as well as study and preparation of larger ones.

In the event some of you might be interested in preparation of a fossiliferous shale for "picking" a simple technique is given here, which also works if one is just looking for small specimens. Fill a coffee can or an old pot about half way with shale, add water, and bring to a simmer (not boiling). Add a table spoon of baking-soda and let it simmer for about five minutes, turn off fire and allow to settle down, then slowly pour off the water. Don't get in a hurry or you will also pour off the microfossils. Add water and decant, slowly, time and again until the water stays clear. Do not do this in your home unless you have a special trap for silt and even that might not be infallible. You will most certainly end up with a plumbing bill unless you do this in your yard. Allow your sample to dry and spread out on a newspaper. For size separation of the residue take hold of one end of the paper and lift. As the residue rolls back and forth the "fines" will sort to the bottom and the course to the top of the ridge. Years ago I used a teaspoon to pick up some of the fine and tap a bit out on a flat surface and put that under the microscope. If rich a teaspoon partially full can provide many hours of pleasure. To "pick up" the microfossil a very fine camelhair brush is used. For a specimen container a capsule can be used. I would punch a few holes in a cardboard tray and place half a capsule in each. All of this is very primitive and there are many alternative, more effective processes, like washing through a nest of screens after the shale is broken down. A final very fine screen is obviously needed to catch the minute specimens. The mesh should be 150 micrometer (=.0059 inches) or U. S. Standard No. 100.

* * * * *

The saga of Tytthocrinus Weller (1930, p. 35) is finally resolved to my satisfaction thanks to the swarm of specimens picked by my wife, Christina, from the marl we obtained at Lake Valley, New Mexico. I was almost certain that the smaller specimens possessed three circlets of plates and lost the lowermost circlet during growth which turned out to be an illusion caused by the shape of the basals at the younger stage. So it is that juveniles have only two circlets of plates (three basals and five orals). Eventually five small radial plates appear between these two circlets, although they were probably never functional as arm bearing elements, and the genus Amphisalidocrinus Weller (1930, p. 34) became the mature form of Tytthocrinus. The genus Octocrinus Peck (1936) has already been referred to (synonomized with) Tytthocrinus (see Treatise on Invertebrate Paleontology, p. T 604). Note that Tytthocrinus was proposed in 1930 by Weller on page 35 and Amphisalidocrinus on page 34. The rule of "page priority" applies in this instance so Amphisalidocrinus will be the surviving genus and the other two genera will be placed in synonomy with it.

It has been very difficult for me to accept the fact that plates may be intercalated in post-larval stages of growth, that is, after the skeleton has been formed and articulated even though I have known for many years that the phenomonon takes place in the Acrocrinidae. Yury Arendt in 1979 demonstrated the late appearance of radial plates in an excellent growth series of the microcrinoid Cranocrinus from Russia. As a matter of vact the Arendt monograph on the codiacrinids is one of the most comprehensive studies ever attempted for this group.

From a letter Harrell wrote December, 1982: "I am not very good with words. To me geology and more particularly paleontology is the most fascinating subject I have ever encountered in my four score and ten years (soon plus one) sojurn on earth. Here is a subject which any person, a butcher, a preacher, a farmer, a housekeeper, a salesman, anyone at all can enjoy and, in fact, there are people in almost all categories who have participated. It is mind boggling when one stops to consider that one can pick up a bit of rock and see a form of life that was living millions, perhaps hundreds of millions of years ago. The next step is to endeavor to learn more about the creatures which then often leads to the desire to share what one has learned with others. In any event it seems that I try to pass on everything. I'll leave it to you to decide what is useful and what is not."

And from a letter to Al Hartman from Harrell about his own friend, "It is like having the door closed and locked on a storehouse of invaluable information." How fortunate we are to have as much of that "storehouse of invaluable information" that Harrell left behind. He pointed the way, the rest is up to us.

Many thanks to each of you who helped to make this a special EXPO Edition.

Madelynne

The Mid-America Paleontology Society (MAPS) was formed to promote popular interest in the subject of paleontology, to encourage the proper collecting, study, preparation, and display of fossil material; and to assist other individuals, groups and institutions interested in the various aspects of paleontology. It is a non-profit society incorporated under the laws of the State of Iowa.

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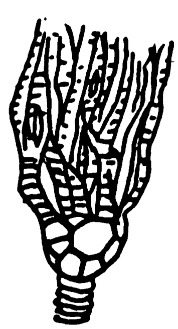

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